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Master Plan and Design of a Low Income Housing Complex for the Friendly House

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Master Plan and Design of a Low Income Housing Complex for the Friendly House

A Major Qualifying Project submitted to the faculty of
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in partial fulfillment of the requirements for the Degree of Bachelor of Science.

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Abstract

Friendly House, a non-profit organization in Worcester Massachusetts, is looking to expand their current facilities to accommodate their growing clientele of the less fortunate members of the community. The team was tasked with determining how to incorporate new facilities into their current site, which imposes many topographic restrictions. The project group developed a master plan for the site, placing an emphasis on a low-income transitional housing complex that would house food services and provide a source of income for the Friendly House during construction services and beyond. The site design integrates a new main facility, additional parking and recreational space, and a complete architectural and structural layout for the new transitional housing complex. This new site layout and housing complex satisfies the needs of the Friendly House but further research of additional components should be conducted to determine whether or not the project is economically feasible.

Fulfillment of Capstone Design Requirements

ABET certification requires a Capstone Design Experience that incorporates skills obtained in the classroom with real world engineering standards and realistic constraints. This section outlines the design problem, approach, and realistic constraints of this MQP that fulfill the Capstone Design requirements.

Design Problem

The project focuses upon a potential new site design for the Friendly House of Worcester, MA. Due to the recent expansion of services provided by the Friendly House, the Director is looking to expand the current facility and reshape the layout of the site. It was the team's responsibility not only to design a master plan, but also to architecturally and structurally design a new building and provide a cost estimate and schedule for this potential new building.

Approach

The team first studied the conceptual needs and space requirements of the Friendly House while exploring the current site conditions. Based off of these observations, a structured site design was prepared that includes a new main facility adjacent to the existing gymnasium, a low income housing complex, expanded parking facilities, and additional green space for outdoor activities. The team then focused on the architectural and structural layout for the proposed housing complex, along with a schedule and cost estimate to construct this building. The site plan and building design were developed with sustainability in mind to accommodate present needs, but also allowing for future expansion to occur.

Realistic Constraints

The Capstone Design requires that engineering standards are used while considering realistic constraints. This section outlines the constraints that were met in the completion of this MQP. As discussed below, this report considers economic, environmental, sustainability, manufacturability, health and safety, and social/political constraints.

Economic, Environment, & Manufacturability

The project as a whole presents a realistic economic constraint to the Friendly House as a project of this size requires a considerable amount of funding. The team was forced to alter and eliminate specific components of the design in the interest of saving money. One of the ways in doing so was designing green features that would limit energy costs and provide a building which is energy conscious and environmentally friendly. Features such as Agriboard sandwich panels and a green roof were implemented to regulate storm water runoff and control the loss of energy through the building envelope. In addition to these green features, the architectural and structural materials used were chosen with manufacturability and constructability in mind. For instance, pre-manufactured and easily assembled materials reduce the project duration and labor cost associated with it.

Health & Safety

Health and safety concerns were also considered throughout the project duration. The site layout allows for safe and convenient pedestrian flow and provides accessibility to the handicapped as well as considers all applicable local zoning requirements. The housing complex was designed in compliance with all relevant building codes to address issues such as fire protection and means of exit. To help promote the general welfare of its occupants, the building layout considers all architectural guidelines necessary for this type of structure.

Social & Political

Throughout the duration of the project, social factors played a large part in the decisions made by the team in design. The team recognized the importance of the Friendly House to the surrounding community and its need to continually expand to serve the growing population. In order to accommodate the needs of the Friendly House along with those of the City of Worcester, there was constant collaboration between the team and the respective parties. Changes in the project scope that occurred were reflective of the concerns and requests of these two parties and ensured that final design satisfied everyone and provides a realistic solution to their current problem.

Acknowledgements

The team would like to thank all those who helped make this project possible. The following individuals were indispensable in the completion of the project, and the group owes great thanks for their guidance and assistance. The group would also like to thank the Friendly House staff along with the many other individuals who offered their support.

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Authorship

All members of the team played active roles in completing this project. Each section had a primary and secondary author, as indicated in the table below, and was then reviewed by the group as a whole so that everyone's input and expertise could be utilized throughout the report.

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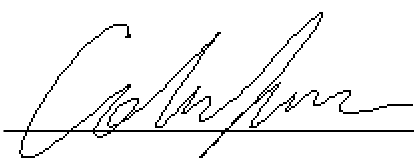
Abstract	ALL	
Fulfillment of Capstone Design Requirements	ALL	
Chapter 1: Introduction	CRK	CAC
Chapter 2: Background	CAC	
2.1 History of the Friendly House	CRK	CAC
2.2 Similar Projects by Non-Profit Organizations	CAC	CQ
2.2.1 Boys & Girls Club of Worcester	CAC	
2.2.2 Project Place	CAC	
2.3 Sustainability in Building Design	CAC	
2.3.1 Green Roofs	CAC	CQ
2.3.2 Energy Efficient Structural Panels	CAC	CQ
2.4 Computer Applications Used in Analysis and Design	CAC	
2.4.1 AutoCAD Civil 3D	CAC	
2.4.2 Autodesk Revit Architecture and Revit Structure	CAC	
Chapter 3: Design Process	CRK	
3.1 Evaluating the Existing Conditions	CAC	CRK
3.2 Identifying the Needs of the Friendly House	ALL	
3.3 City of Worcester Involvement	CAC	CRK,CQ
3.4 Master Plan	CRK	
3.5 A More Practical Master Plan	CAC	
3.5.1 Site Design	CAC	
3.5.2 Building Layout	CAC	
3.5.3 Parking	CAC	CRK,CQ
3.5.4 Walkways and Stairs	CAC	
3.5.5 Handicapped Accessibility	CAC	
3.5.6 Recreational Space	CAC	
3.6 Design of a Transitional Housing Complex	CAC	
3.6.1 Space Requirements	CRK	CQ
3.6.2 Compliance with Local Zoning Requirements	CRK	
3.6.3 Criteria for the Structural Design	CQ	

3.6.4 Architectural Design	CRK	CQ
3.6.5 Exterior Façade	CRK	
3.6.6 Schedule	CQ	
3.6.7 Cost Estimate	CRK	CAC
Chapter 4: Results & Conclusions	CAC	
4.1 Master Plan	CAC	
4.2 Low-Income, Transitional Housing Complex	CRK	
4.3 Future Projects	CQ	
4.4 Final Thoughts and Thanks	ALL	
Appendix A: Detailed Space Requirements	CQ	
Appendix B: Structural Calculations	CQ	
Appendix C: Detail Drawings	CQ	CAC,CRK
Appendix D: Detailed Cost Estimate and Schedule	ALL	

The signatures below indicate acceptance of the above.

Cory Cormier



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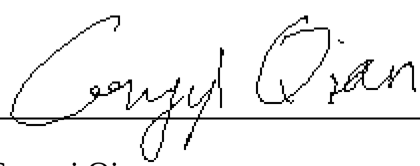

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Table of Contents

List of Figures

Appendix C:

List of Tables

Chapter 1: Introduction

The Friendly House project is aimed at developing a new and much larger facility that can host a series of activities and programs that the Friendly House currently provides and would like to provide in the near future. The second main purpose is to find a way to generate a source of income to allow this expansion to occur. This multi-dimensional project encompasses site development, project planning, and building design. In the effort to encompass the needs of all the parties involved, an investigation was conducted to determine the requests of Friendly House staff members along with those of the City of Worcester. Considerations highlighted were the need for a larger kitchen facility, more classroom space for the children, and an outdoor recreation area that would serve individuals of all ages.

The number of individuals seeking help from Friendly House has increased over the years due to the struggling economy not only in Worcester, but the United States as a whole. Due to this increase, a much larger facility that offers additional programs is necessary. A major concern of this project is to find a way to avoid shutting down Friendly House's critical programs such as their food program and youth services during construction, so that the people in need are not neglected. Therefore, the team was tasked with developing a master plan that can be broken up into several sequential phases that will allow continuous flow of activity while completing a full construction of Friendly House facilities.

As part of the master plan, the team determined that the most feasible way activities could continue to operate at full capacity during construction would be to re-locate the Friendly House's programs to a nearby facility. A low-income transitional housing complex was integrated into the final design of Friendly House facilities to accommodate the program's needs during the construction process. This facility will then transition into two-stories of housing apartments along with space for a full kitchen and cafeteria on the lower floor that can assist Friendly House in their rapidly expanding food services program.

Once the general square footage requirements for the low-income transitional housing complex were determined, extensive research was conducted and several designs were developed to incorporate all the necessary architectural and structural requirements. Architecturally, the project group looked at factors such as building codes, space requirements for activities, privacy concerns, and the general functionality of the building. During the structural design phase, the team placed emphasis on proper sizing of columns, girders and beams, by looking at the layout of the building and performing calculations from different types of loads; and at the same time considering the most economical and environmentally friendly design.

The final results of the project show the master plan and design of the low-income transitional housing complex according to the needs of Friendly House, as expressed by staff members in the beginning phase of the project. The combination of the new Friendly House facility and the transitional housing complex will allow the Friendly House to continue expanding its services and keep them available to residents throughout the entire construction process. However, the team believes that in order for the project to be completed within a reasonable budget that could be financed by Friendly House and the City of Worcester, additional work needs to be completed to form a compromise between the expectations of the organization and its realistic economic feasibility.

Chapter 2: Background

To complete the task of developing a master plan and designing a low-income, transitional housing complex, the project team found it necessary to conduct background research involving the main components of the project. Preliminary information on the history of the Friendly House was gathered to learn the organization's past accomplishments and goals. These could then be mirrored and built upon in the future with the help of the new facilities. The team also researched similar construction projects that have been initiated by non-profit organizations to see what design concepts worked best and incorporate them into both the master plan and the design of the housing complex. In addition, the project group wanted to gain insight on different sustainability components that could be added into the design of the housing complex. This chapter provides basic information regarding methods to make the building envelope "greener" by means of energy efficient exterior walls and roof. Since the final design needed to be produced using multiple forms of civil engineering software, this chapter also provides basic information regarding the basic capabilities of these programs and their application to the project.

History of the Friendly House

Friendly House, originally a small settlement house for immigrants in Worcester MA, was founded in 1920. Its purpose was to "promote neighborhood health and welfare for the betterment of Worcester and to further the interests of Worcester's immigrants" (Friendly House, "About"). This included providing a sense of community and neighborhood health, while introducing them to the culture and traditions of Worcester. This three-room settlement house offered classes in housekeeping, cooking, and sewing for the women, while the boys underwent manual training. The friendly house was not all hard work, as social gatherings were also planned and greatly enjoyed.

As a few years passed by, and demand for such services grew, Friendly House expanded not only in facilities, but also in what they had to offer. A pre-school nursery, dental clinic, and first aid were only a few of these additions. The new location on Wall Street, obtained in the late 1920's, offered much more capacity and a spacious playground, creating a better sense of community.

In 1928, Friendly House became an independent, not-for-profit organization, with its very own Board of Directors. Despite this promising accomplishment, the following decade presented Friendly House with continual challenges as the Great Depression hit. More and more individuals turned to Friendly House for guidance, shelter, and opportunity. During this time period, Friendly House became involved in government supported programs for the first time. With commitment and determination, Friendly House was able to survive during the tough economic times and earn the respect of many.

In 1939, Friendly House expanded further by adding a Mother's Club. This program allowed the mothers and grandmothers of the children of Friendly House to participate not only in household activities, but also in field trips to local industries, with the hope of educating and Americanizing these women. However, this focus did not last long as World War II began soon after, requiring much of the older individuals to serve. With the men in the armed forces and the women in defense positions, the focus shifted back to the children as the Nursery School was filled to capacity. This focus on school-aged children remained the primary focus of Friendly House after the completion of the war. Music, arts and crafts, nature programs, and summer trips are just some of the many activities provided for children by Friendly House.

Throughout the 1950's and 60's, Friendly House faced challenges similar to those of the rest of the country with the rising poverty levels amongst inner city neighborhoods (*Friendly House History*, 2010). However, with the hiring of its first Program Director, Gordon Hargrove, Friendly House would continue to alter its programs and services to fit the needs of the community. After receiving a grant of nearly $10,000 from the Office of Economic Opportunity, Friendly House was able to reshape its programs to provide social services to approximately 2,000 needy residents. The expansion of services not only provided an immense amount of help to the surrounding community, but sparked the growth of the Friendly House that resembles the organization that it is today.

With its continued growth and financial support from the community, Friendly House was able to construct a new facility on the site of St. George Orthodox Church, seen in Figure 1, which was located next door to the existing building. In addition to the new facility, Friendly House was able to in initiate new programs such as the Head Start Program and a new child feeding program in the early 1970's. Friendly House began creating programs for teens, elders, and families that focused on improving negative aspects of the community, such as the rising crime and drug problems in the Worcester area. By 1983, Friendly House had established an emergency shelter for homeless families at its current location of 36 Wall Street, becoming the first agency in the state of Massachusetts to provide USDA surplus foods to needy families in the community. Friendly House maintained continued involvement with the United Neighborhood Center Association (UNCA) and helped establish the Oak Hill Community Development Corporation, which is still providing services in Worcester.

Figure 1: Current Friendly House Building

Friendly House is now a United Way agency and works in cooperation with other outreach centers such as the Centro Las America, and the Henry Lee Willis Neighborhood, and continues to grow with funds from various federal, state and local grants. With several other neighborhood centers in Worcester being forced to close down, Friendly House has become the leader in providing services to any needy residents, by providing “shelter, emergency help, food, medical care, after school and summer programs, day care, senior programs and counseling” (*Friendly House History*, 2010). In 2010 alone, approximately 25,000 residents received assistance from the Friendly House, while an additional 3,000 residents sought help from Friendly House’s Social Service Department. Friendly House continues to have a tremendous impact on young people by proving a safe environment, where kids can grow, learn and have fun, away from the inner city streets of Worcester.

Similar Projects by Non-Profit Organizations

To assist in design possibilities for the new facility and transitional housing complex, the team researched several projects that have successfully been built to accommodate social service programs, similar to the ones provided by Friendly House. Common practices involved in these projects could be observed and potential problems could be recognized. Through this research the team learned from projects that have already been constructed so that related design components could be included in the master plan.

Boys & Girls Club of Worcester

Opened in 2006, the Boys & Girls Club of Worcester recently built a new 50,000 sq. foot facility (see Figure 2 below) that incorporates many of the same features in its design as Friendly House (Boys and Girls Club of Worcester, 2012).

Figure 2: Boys & Girls Club Facility (*Programs & Services*, 2012)

Similar to Friendly House, the Boys & Girls club of Worcester sought to incorporate education, recreation, and general support space for the people that will utilize its services. To accommodate several different recreational services, the Boys & Girls Club facility has 19,500 sq. feet of athletic space including a gymnasium with a high school basketball court, two cross-courts, a volleyball court, and an exterior basketball court. The gymnasium also has plenty of space for locker rooms and shower facilities. Additionally, the new design has a wellness center, a boxing ring, an indoor miniature baseball field and a natatorium with a six-lane competitive pool.

The facility provides plenty of space for the organization's services to thrive and to give its clients an abundance of room to participate in learning activities such as computer lessons, art lessons, and music lessons, as well as locations to play board games or do homework. This portion of the building is over 5,000 total sq. feet and is separated into two major program areas, divided by a lobby in the center. Included in this space are conference rooms for executive personnel to conduct meetings and host teen group clubs. These teen clubs practice leadership skills or participate in programs that strive to educate teens on positive behaviors to enhance the own well-beings and live healthier lives. The architects for the project, Bargmann Hendrie & Archetype Inc., stated that this section of the facility was designed to complement the outdoor environment of the area, as its floor plan runs in a similar pattern to the train tracks located outside of the building (Recreation Management, 2007). Since the new Friendly House facility will be incorporated into existing site components, much like the Boys and Girls Club, it will also be important to compliment the building layout with a smooth transition from the outside environment.

The Boys & Girls Club also provides food services to the Worcester community, and like Friendly House, needed a new café and full service kitchen to serve food and hold events. The café and multi-purpose area takes up approximately 3,800 sq. feet. Friendly House looks to design a similar type of space for its food program, but would require additional square footage to accommodate a larger café area that can hold more people for events.

Project Place

Located in Boston, Massachusetts, Project Place is a non-profit organization that aims to create jobs, offer skills training, and supply housing to needy individuals in the downtown Boston Area (Project Place, 2012). Recently, Project Place moved to their new "green" facility to allow for the expansion of its programming and social services, and to provide a greater amount of affordable housing to those in need. Similar to the Friendly House's goals of a transitional housing complex, Project Place's facility, pictured in Figure 3, is separated into 14 efficiency housing units on the top two floors while the remaining six stories are occupied by a commercial kitchen, conference rooms, classrooms, employee workspace and retail restaurant space (*Consigli Featured Projects*, 2012).

Figure 3: Project Place Facility (*Consigli Featured Projects*, 2012)

The new Project Place facility is especially significant in the research for the Friendly House facility because it is an environmentally friendly building and, most importantly, incorporates the design of low-income affordable housing into the building plan. The project group could see how similar housing has been effectively laid out for its residents. The 14 efficiency housing units are relatively small in size and have numerous different floor plans (Lane, 2007). Two of the fourteen units are handicap accessible and each unit includes a bed, nightstand, dresser, desk, and dining room table (Project Place, 2012). In addition, all units have a private kitchen with all the necessary appliances and bathrooms with shower stalls. Amongst many considerations from the designer Dennis Duffy, a major concern was to ensure that the housing units were designed in a way that could be easily maintained. It was thought that there would be routine turnovers between residents because the purpose of the housing is more to provide a temporary place to gain skills and monetary power to achieve a better state of living (Lane 2007). In addition to housing units, there are common rooms available to residents as well as a separate laundry room and trash room.

The Friendly House made suggestions to the project team that the low-income transitional housing complex should incorporate sustainable features, making the facility environmentally friendly and energy efficient. Thus, it was important to take notice of the "green" components that were used in projects like Project Place. In their transitional housing, the floors are constructed primarily with recycled rubber and the walls have been decorated with environmentally friendly paint (Lane, 2007). Most importantly, a geothermal heat pump will provide heat and air conditioning for the complex, cutting the utility costs by an estimated 40 percent. The heating element and open grill for air conditioning occupy a small space on the wall of each unit. The Project Place set out to achieve "Gold" level certification within the U.S. Green Building Council's Leadership in Energy and Environmental Design standards, which is more commonly known as the LEED ratings.

Sustainability in Building Design

Sustainable building designs often seek to achieve a desired LEED Rating (Leadership in Energy and Environmental Design) and to cut on energy costs. LEED certification "provides a third party verification that a building was designed and built with strategies aimed at achieving high performance in five key areas of human and environmental health: sustainable site development, water saving, energy efficiency, material selection and indoor environmental quality", (*What LEED Delivers*, 2011). If the design of the Friendly House housing complex can be recognized by the government for being sustainable or even LEED certified, it may be able to receive additional stipends to help fund the project. Additionally, a sustainable design will help conserve energy, making it possible for Friendly House to save money. However, for this to be accomplished, sustainable building strategies needed to be looked at during the developmental stages of design.

Green Roofs

Installing a green roof on top of the low-income housing complex would be one viable solution to make the building more sustainable. It was important for the project team to understand the functions of a green roof as well as look at similar designs that have previously been built. Traditionally, a green roof system consists of a lightweight growing soil and vegetation planted over a water resistant membrane, seen in Figure 4.

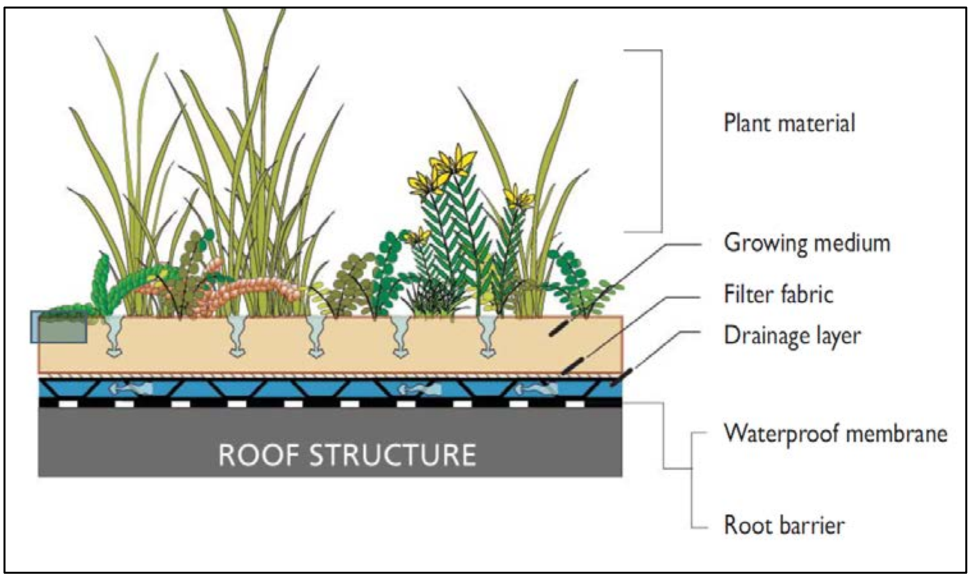

Figure 4: Green Roof Structure (*Install A Green Roof*, 2011)

Its purpose is primarily to act as a method for storm water control by holding the storm water in the vegetation reducing run-off on site and promoting evapotranspiration (Philadelphia Water Department, 2011). In addition to reducing runoff, green roofs can have other benefits such as reducing the cooling and heating costs of the building, extending the roof's lifespan, and even improving air quality by filtering dust particles. Another benefit of a roof garden is an increased R-value. Typically, the growing media of a green roof exhibits an R-value of 5 per inch of thickness (*Method for Determining the Resistance*, 2000). Therefore, a standard green roof with 3 inches of growing media would achieve an approximate R-value of 15, not including any other elements of the roof structure. Since a green roof is intended to filter storm water, special considerations must be made when selecting the waterproof membrane in order to protect the structural integrity of the roof. Green roofs will cause an increased amount of stress on the roof members; therefore structural calculations must take into consideration the added loads. Further explanations of the associated loads are discussed in later sections.

One local project, seen below in Figure 5, which was completed in 2008 with a green roof design, was the East Hall residence building at Worcester Polytechnic Institute (Martinelle 2009). East Hall's signature feature, the living green roof, was the first of its kind in the city of Worcester. The roof consists of approximately 5,000 square feet of sedum, chives and several other types of plants on top of 12,900 square feet of Energy Star roofing. In 2009, the building was awarded the Gold LEED certification for its roof design as well as several other sustainable features.

Figure 5: WPI East Hall Green Roof (Martinelle, 2008)

Energy Efficient Structural Panels

The housing complex can also incorporate sustainable design through the use of energy efficient structural wood panels. These panels can be used as load-bearing walls or they can simply be attached to the structural frame of the building. One particular brand of this product is called Agriboard, pictured below in Figure 6. The panels are composed of compressed wheat straw with a timber stand sub-frame (*Agriboard Panels*, 2012).

Figure 6: Agriboard Panels (*Agriboard Panels*, 2012)

Due to the increased efficiency of factory assembly and reduced on-site construction time, the installation of Agriboard is relatively inexpensive. Most importantly, once they are installed, the lower life-cycle energy costs will save Friendly House valuable money over the long-term. Agriboard can increase energy efficiency and cut energy costs because of its ability to be more air tight than other construction materials. In fact, Agriboard has been shown to be up to seven-times more effective at controlling air inside a building compared to traditional methods. This results in the building requiring less energy to heat or cool it and helps maintain a consistent temperature throughout the facility. As additional proof of its energy efficiency, Agriboard panels exhibit an extremely high R-value, meaning that it is very resistant to heat flow through the material. Currently, Agriboard offers panel in 4 inch and 8 inch thicknesses that have R-values of approximately 13 and 25 respectively. In parallel, Agriboard panels have a greater thermal mass, which helps regulate the changes in temperature throughout the day and therefore less money needs to be spent on altering the temperature within the building.

The exterior walls and roof are the two main components that comprise the building envelope, which is where the majority of the energy is lost. By using a green roof and Agriboard panels the building envelope achieves a greater R-value, which means that less energy is lost and more money is saved.

Computer Applications Used in Analysis and Design

Over the course of the project, it was critical for the team to utilize available computer applications in order to visually display the final design work. The three main programs used by the group were *AutoCAD Civil 3D*, *Autodesk Revit Architecture* and *Autodesk Revit Structure*. Therefore, it was important to understand the general capabilities of each program before beginning the design process, so that each one could be effectively and efficiently used.

AutoCAD Civil 3D

AutoCAD Civil 3D is a civil engineering software used by engineers, drafters, designers, and technicians that work on projects involving transportation, land development, and water resources among many others (*AutoCAD Civil 3D Features*, 2012). The main reason this program was selected by the project group was because of its capabilities to easily display plan sets and create profiles from alignments. The program's display styles, annotation features, and easy drafting tools make it the best choice for modeling the existing conditions and designing the master plan.

AutoCAD Civil 3D also allows for GIS information to be converted to a drawing file, so that it can be used as a 3D surface utilized to show important information regarding the existing conditions. Specific to this project, the 3D surface was used to create profiles that show the changes in elevation along a given piece of land. By converting a simple polyline into an alignment the software can then show the changes in elevation along that alignment based off 3D contour lines across the site. The *AutoCAD* program makes this process relatively straight forward and allows multiple profiles to be created in a short amount of time. The team wanted to capture profile information across several cross sections of the Friendly House site requiring an effective program like *AutoCAD*.

Autodesk Revit Architecture and Revit Structure

Autodesk Revit Architecture and *Revit Structure* are a type of Building Information Modeling software that can be utilized in design as a 2D drafting element as well as a parametric 3D model (Dzambazova et al. 2010). *Revit Architecture* is extremely useful because a user can create a model for a building, layout its floors plans with furniture, and then finally render the drawing into a real-life 3D image. Essentially, once the final size of a building has been determined, *Revit Architecture* can be used to lay out precisely what the inside of the building will look like. For the purpose of the project, this function is the most appealing capability. Whether it is the type of flooring, window sizes, stairwell locations, or kitchen layouts, *Revit Architecture* can incorporate nearly every detail of design into the building's final representation. Once all details of the design have been determined, the 3D components allow third parties to see what the building should look like as if it were built. This capability is critical in this project setting because other parties will want to see the final design before deciding to make any financial or time investments.

Similar to *Revit Architecture, Revit Structure* allows nearly every piece of information regarding a building's structural layout to be displayed both in 2D and 3D modeling. In 2D plan view, users are able to see the locations and sizes of beams, columns, girders and any other structural components. This makes it extremely convenient to visually show the number of each type of beam or column that is required for a building. A simple, yet very informative setup in its 2D view allows the project team to convey important structural information to third parties with relative ease. Although *Revit Structure's* 3D components are very advanced, its capabilities will only be touched upon slightly during the course of this project but it will still allow third parties to view the building's structural elements. Within this view it will be difficult to convey sizing and strength information, but it will allow third parties to see that the locations of the beams, columns and girders can be implemented without compromising the building's architectural layout

Finally, it is important that Autodesk's Revit programs are used throughout the design because data, models, plans and many other types of information can be transferred from one program platform to another (*Coordinating and Sharing Information*, 2007). This makes it possible to incorporate features of each program into one final display of the design including nearly every component of the building.

Chapter 3: Design Process

Several months prior to the initiation of the project, the team developed a well-defined scope of work that would satisfy the needs of Friendly House. In April 2011, meetings began with the Executive Director of Friendly House, Gordon Hargrove, along with WPI professor and member of the Friendly House Board of Directors, Bill Baller, and Architect Dan Benoit, to discuss possibilities for the development of the land owned by the Friendly House. Additionally, it was critical for the team to become familiar with the land owned by Friendly House, the City of Worcester, and nearby residents to further identify the scope of work. Therefore, the project group was led around the Friendly House's and neighboring properties to get a first look at the existing conditions of the properties, as well to gain knowledge regarding the different lot sizes and property boundaries. Although it was difficult to predict what the final scope of work would be, this preliminary visit at Friendly House, allowed the group to get a general understanding of the project and gain an understanding its' major goals.

After several meetings with the individuals involved in the project, a scope of work was finalized that satisfied Friendly House's near and long term goals. Through the use of engineering practices the team would:

1. Identify and plot the existing conditions of all the land and buildings pertaining to the Friendly House expansion, as well as provide descriptions of the land's current condition.
2. Develop a master plan showing the entire property in question, including main buildings, site access, and site uses. The master plan includes "phases" that should be completed sequentially in order to meet the final goals of Friendly House.
3. Identify a list of tasks that should be accomplished in order to complete the phases indicated on the master plan.

4. Provide the architectural and structural design for the low-income, transitional housing complex that is to be used by the Friendly House as a temporary space to host activities during construction and later as an apartment building.

The project's scope of work described above was based mainly off of requests from the Friendly House to meet their future goals. By creating an existing conditions plan, Friendly House will be able to identify the nature of the project at hand. This will also allow future groups involved with the work to easily see the land conditions to accurately estimate the extent of work and its associated costs. The team believed this to be the first step, so that a master plan and its activities can be aimed at transforming the land's current conditions into the Friendly House's desired final product.

In addition to addressing the existing conditions of the property, the master plan's purpose is to advise Friendly House of what the project team believes the final site should look like once all construction phases are complete. Once the master plan has been turned into a reality, Friendly House's goals should be satisfied. The master plan is also accompanied by a construction phase plan because the team recognizes that the property cannot be transformed in one stage without completely disrupting Friendly House services. This will allow future groups who work with Friendly House to identify the steps required to complete the master plan.

Finally, the most significant portion of the project focused on one particular phase; the design of a multi-purpose facility that will be eventually transformed into a source of income as a low-income apartment complex. This process included the architectural and structural design of the building and its integration on the site. Among other tasks, the group sized the building, laid out its floor plans, and designed its structural members to ensure that the layout of the building would be structurally sound. However, before this could be completed, the existing conditions needed to be identified.

Evaluating the Existing Conditions

In order to accurately depict the existing conditions of the Friendly House property, the team needed to incorporate many engineering components. These included on- site surveying, evaluating land conditions, determining property boundaries, and utilizing the field information by inputting the data into software such as GIS, and *AutoCAD Civil 3D*. The field work was essential to gather accurate data for both the existing conditions plan and the master plan, while the computer software allowed the findings to be plotted clearly and presentably to Friendly House and the City of Worcester.

To determine the property boundaries and plot them with *AutoCAD*, the team first obtained the deed of Friendly House from Professor William Baller. The deed indicated distances and direction (in the form of coordinates) for the property line that existed around Friendly House. However, the deed itself gave a starting point that appeared to be in questionable condition. Therefore, the group went out on site in an attempt to locate any other property pins to provide more accurate coordinates for the property line. After thoroughly searching the property, no other property line pins were found. This is most likely due to the drastic changes that have occurred on site over the years such as the growth of plant life, the removal of roads, or erosion of soil. To face this dilemma and confirm an accurate starting point, team members visited the Worcester District Registry of Deeds and acquired a plan that showed not only the Friendly House Property line, but also the surrounding lot lines. With the original deed and the acquired plan from the Registry, the team found it necessary to confirm the lot lines on site to ensure its accuracy, as well as ensure that the new plan confirmed the starting point of the Friendly House property line. On site, it was confirmed that the new plan was accurate and the starting point was consistent with the Friendly House deed. From this starting point at the south boundary of the site, towards the east side of Thorne Street, the team was able to layout the boundaries of the Friendly House property and surrounding properties in AutoCAD Civil 3D. Figure 7 shows the property boundaries and ownership of the area surrounding Friendly House.

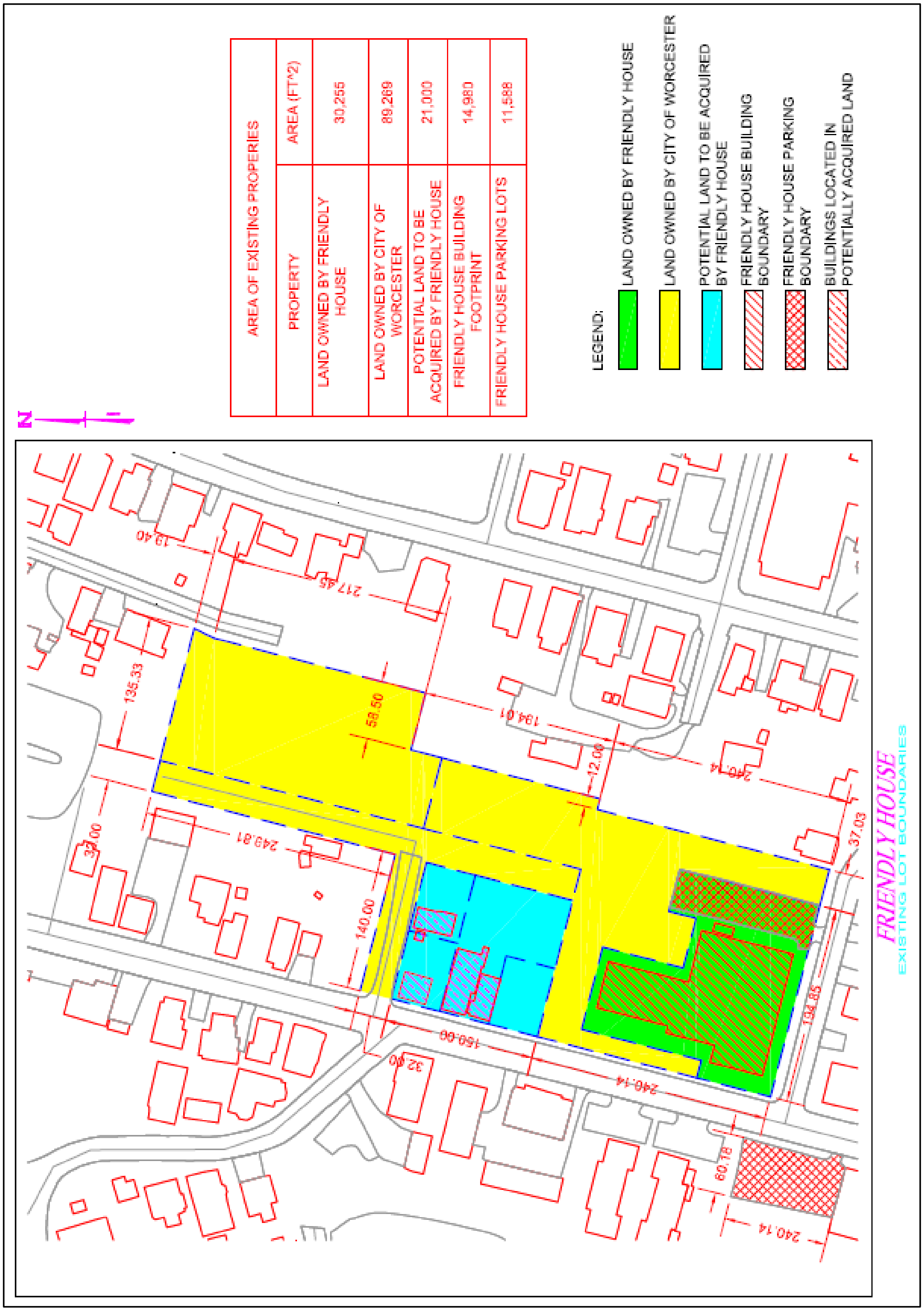

Figure 7: Ownership Breakdown

It was found that the area owned by Friendly House consisted of approximately 30,255 sq. ft. This property extends 200 feet North and 195 feet to the East on Thorne Street. On the Northern end, property owned by Friendly House is confined by the land owned by the City of Worcester. Included in the final square footage of the Friendly House properties is the vacant lot located on the other side of Wall St. In addition to the land currently owned by Friendly House, the team evaluated the areas on both the North and South side of Montreal Street. The lots to the South of Montreal Street, seen in Figure 8 below, were critical to the master plan because if they were to be acquired, the land would provide additional space for expansion.

Figure 8: Montreal Street Properties

This area of land, comprised of 4 different lots, was found to be 21,000 square feet. If eventually acquired, this would give Friendly House approximately 51,255 sq. feet of land to build on and use as recreational land space. The land on the North side of Montreal Street was treated as a "last resort" piece of land. Friendly House would not want to purchase the land if it wasn't necessary, but was willing to do so if it was needed to complete construction or serve as additional parking. Finally, the team calculated the area of land owned by the City of Worcester, so that it could be integrated with the Friendly House land in the master plan. The area owned by the city was found to be roughly 89,269 sq. feet.

With the lot sizes and dimensions in mind, it is crucial to understand the conditions of the site. The Friendly House property currently consists primarily of the existing building, the parking lot, and the vacant lot across Wall St. The building itself has a footprint of 14,980 sq. feet, while the parking lot is approximately 5,595 sq. feet, as pictured in Figure 9.

Figure 9: East End of Friendly House Building and Parking Lot

Both are located on the South end of the property owned by Friendly House. In terms of site conditions, the areas away from the building are well grown in with moderate to heavy vegetation and areas on the South-East end of the site contain shale, making it very costly to excavate and level off. The most noticeable feature of the site that influences the master plan design is the change in elevations across the site. Figure 10 shows the existing topography of the site with all site infrastructures as well as the locations of the profile alignments which are described below.

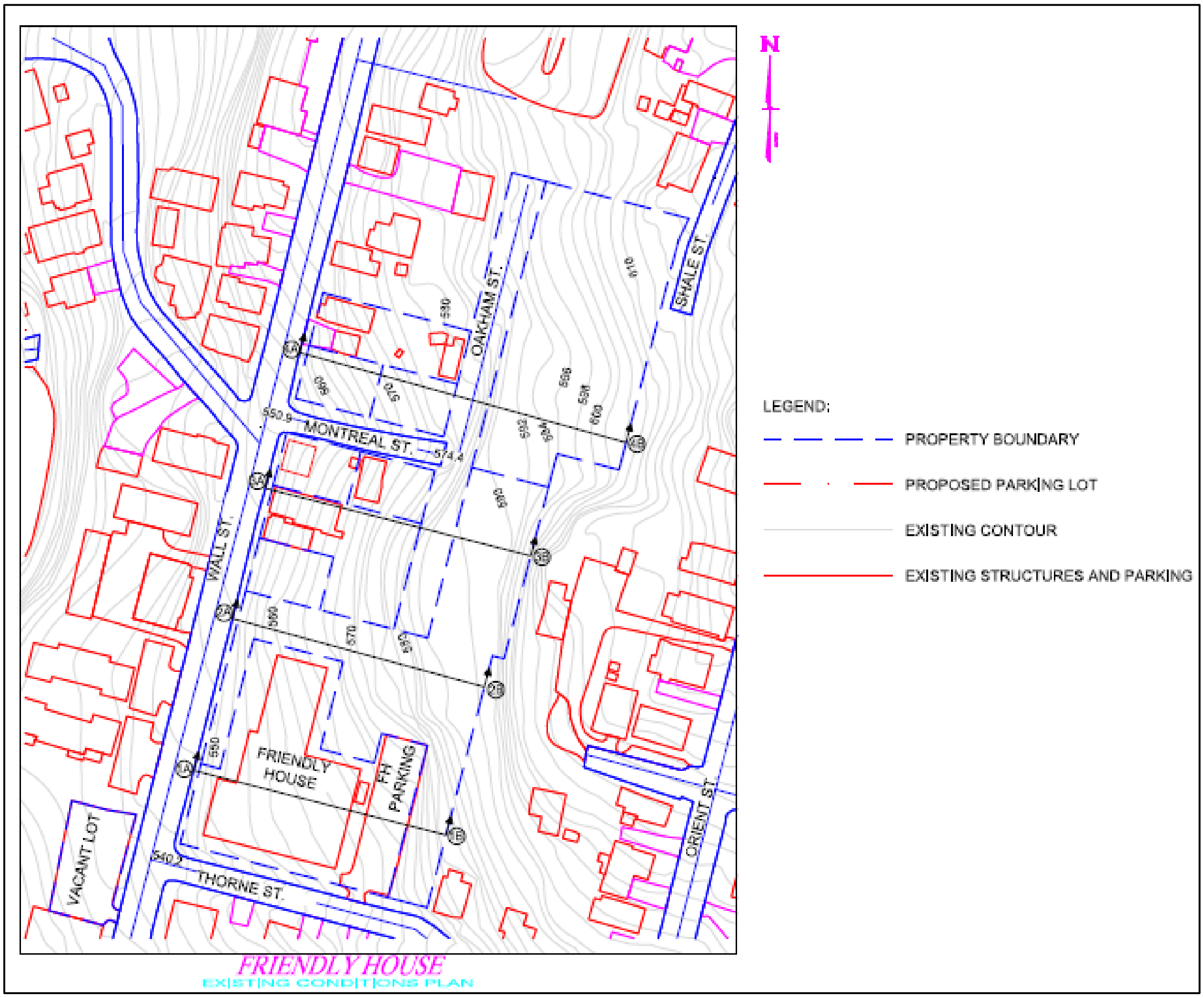

Figure 10: Existing Conditions Plan

Towards the South end of the site near Thorne Street, the elevation changes by 33 feet from East to West. However, this location is already occupied by the current Friendly House and parking lot, so additional excavation in this area will be minimized and the shale to the east of the parking lot keeps the soil stable on that side. This increase in elevation can be seen in the cross section in Figure 11.

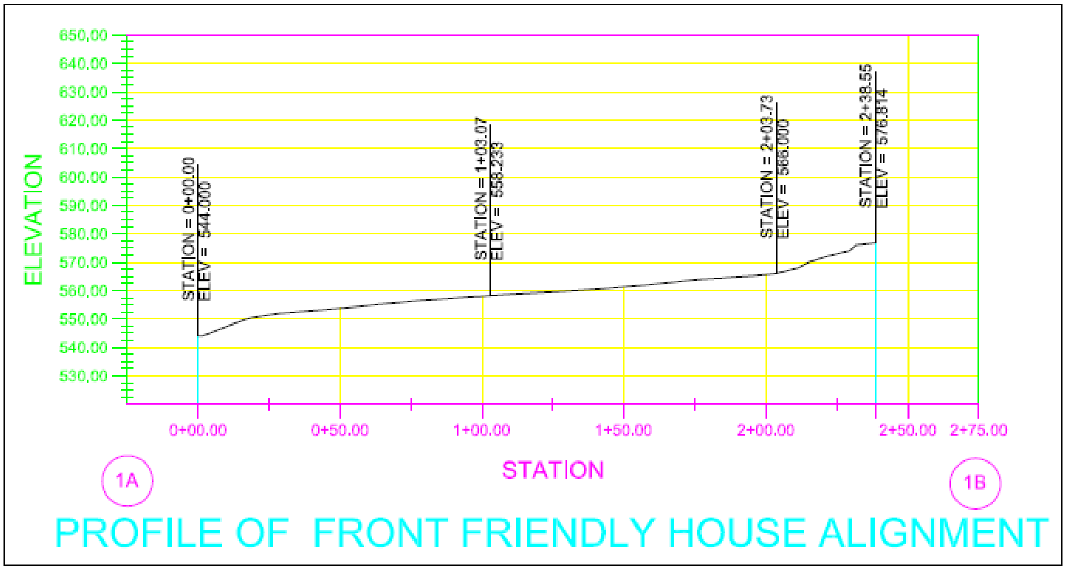

Figure 11: Cross Section: Front Friendly House

Towards the front of Friendly House, the elevation changes even more, as it slopes upward and increases by more than 40 feet. This section of land will need to be leveled off and a retaining wall will be necessary at the north end of the parking lot to prevent soil slippage and erosion. This cross section can be seen in Figure 12.

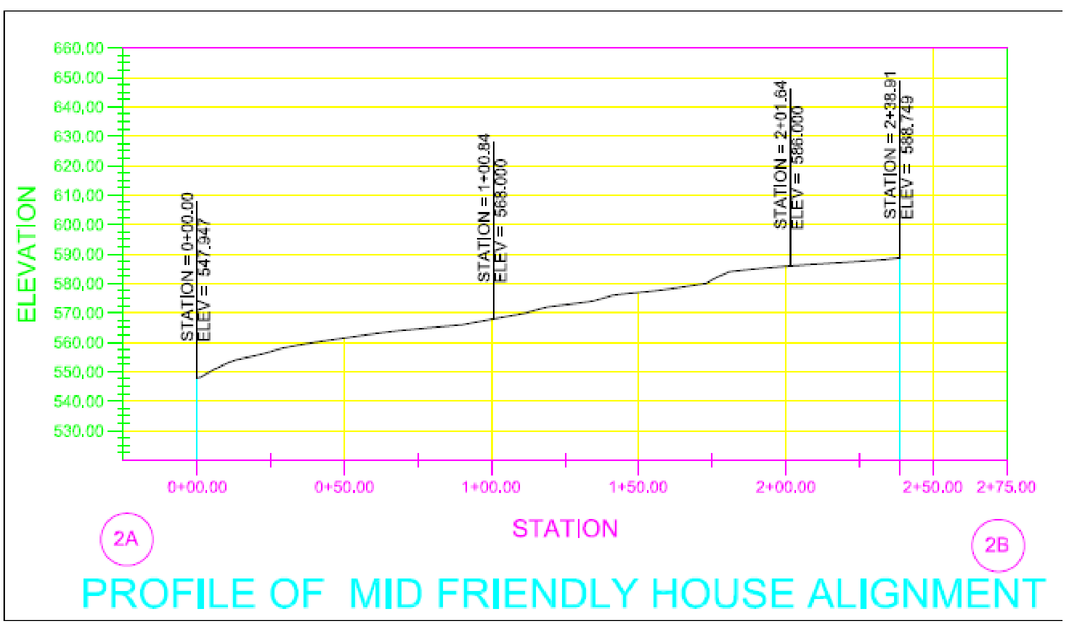

Figure 12: Cross Section: Mid Friendly House

The same approach will need to be taken near the Montreal Street properties, where the elevation changes by over 30 feet. A series of retaining walls, with considerable excavation will be needed to open up the space and make it more usable as recreational area. Below, in Figure 13, the cross sections of the areas around Montreal Street and Shale Street are shown respectively. Following these profiles, Figure 14 captures the drastic change in elevation along the Montreal Street properties.

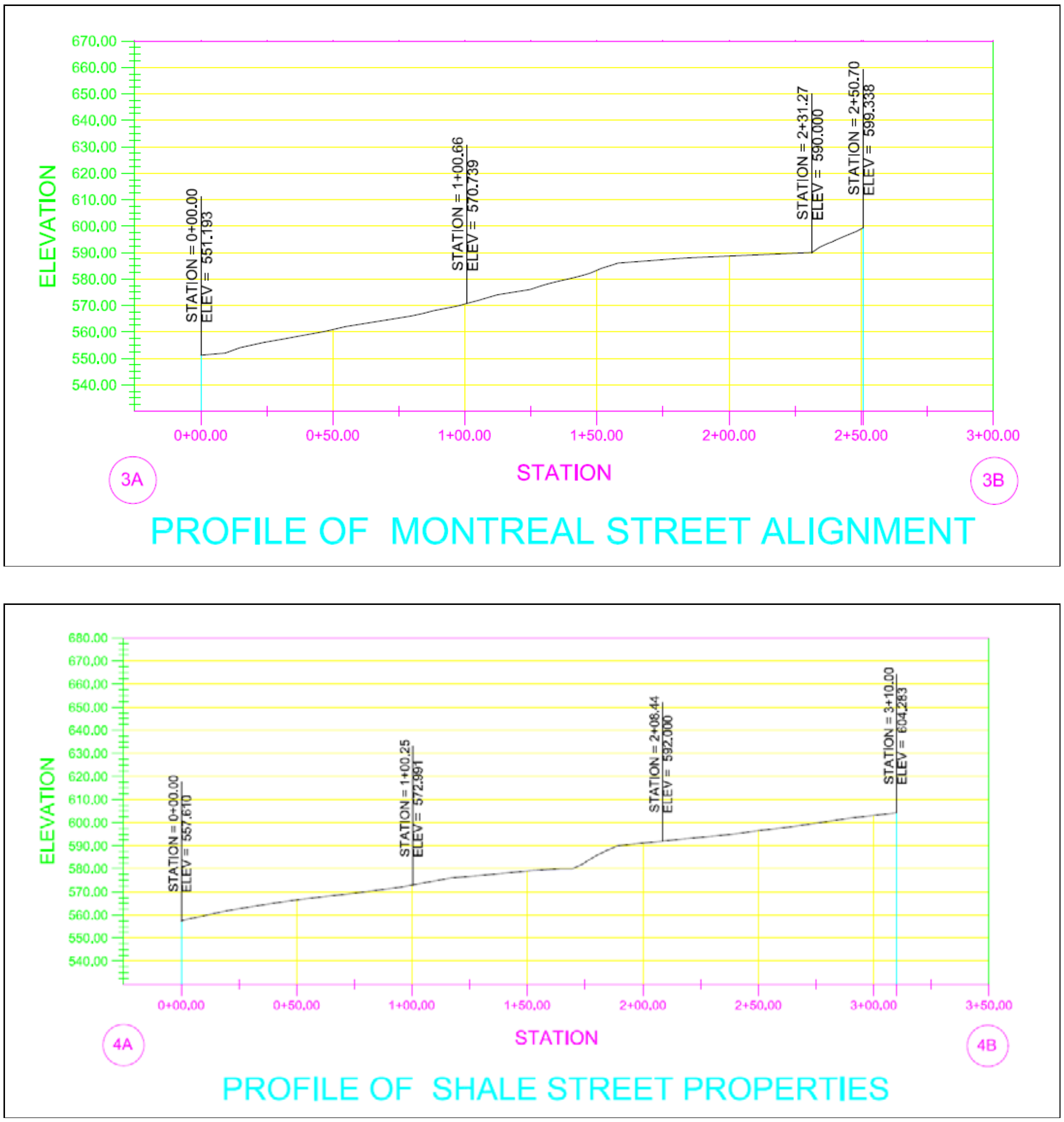

Figure 13: Cross Section: Montreal Street & Shale Street

Figure 14: Existing Conditions of Montreal Street

Overall, the existing conditions make it a difficult process to improve the site so that the construction process can begin. However, if several improvements are made, the site will allow for activities to take place in an accessible environment. If the land is leveled and protected through the use of retaining walls, the existing property can be transformed into an area that will meet the needs of the Friendly House.

Identifying the Needs of the Friendly House

Once the team was able to plot the property boundaries in CAD and fully lay out the existing conditions of the site, it was important to identify the Friendly House's current needs and desires for a new facility, so that the master plan could be designed accordingly. In order to so, the project team met with Friendly House Director Gordon Hargrove, as he detailed the Friendly House's current programs and discussed additional programs in the coming years.

As a general concern, Mr. Hargrove emphasized the need for a larger food storage space and additional rooms for other various programs. Also, the need for air conditioning or some other form of air circulation to keep the children cool during the summer was highlighted. In the past, humidity had driven children away and made the gym floor dangerous due to the moisture. Concerning the development of land to be used for a park, Hargrove was in-different as to the construction means, as long as the end result was a recreational area the community could enjoy.

For the properties located adjacent to Montreal Street, Mr. Hargrove suggested the idea of the low-income, transitional housing complex to offer community housing and provide income to help fund the project as well as future endeavors. In addition, it was insisted that the building be sustainable, in hopes that it will be able to generate more funding from government agencies. Hargrove commented that the addition of this housing complex would then create the need for additional parking. It was estimated that a total of 70 spaces would be needed. In accommodating this need, it would be desirable to use the empty lot across the street from Friendly House, barring no more environmental concerns.

Hargrove expressed his interest in beginning construction on the housing complex as soon as possible. From there, the outdoor space could be expanded not only for the Friendly House children, but also for community members of all ages. The Friendly House vision for such a park includes recreational areas organized as part of a "tiered" system, where each tier could be utilized by a different age group. This layout would provide space for the youngest children at the bottom of the hill and increase age with elevation. Besides the demand for a playing field, the layout of the outdoor space could be designed in several different ways to provide a multitude of different activities.

In terms of programming, an expanded computer lab would be of great use for the children's after school program as well as a multipurpose space that could be used for games, arts and crafts, music, dance and homework. Another program that is lacking in amenities is the social services department. This important division of the Friendly House focuses on immigrants and the social needs of community members. In order to adequately serve these individuals, additional office space and rooms that could be used for private clients are needed. To accommodate employees, more bathrooms and a conference room would contribute to a better working atmosphere.

One of the largest programs that Friendly House offers is their food program which prepares and delivers approximately 2200 meals per day, requiring much space and coordination; both of which are missing in their current facility. Hargrove made it clear that much more space is required for a large kitchen, so that the flow of food production can move logically and quickly, allowing the Friendly House to produce more meals for needy residents per day. Additionally the kitchen needs to integrate a loading dock into the design for ease of deliveries and large fridge/freezer space for storage. The current Friendly House does not have a loading dock and the various fridges and freezers are spread out across the facility, making it difficult to run an efficient food service program

With these general concerns and desires uncovered, the project team coordinated meetings with the directors of the three major programs; youth services, social services, and the food program. These individual meetings allowed the group to ask specific questions regarding the needs and concerns of each program, revealing the space requirements for the new facility design. When interviewing each staff member, it was emphasized that the interviewees should state the needs without regards to their economic feasibility. Taking this approach would allow the team to include as many of the Friendly House's desires in the master plan as possible, and leave room for growth.

After meeting with Danielle Delgado, the Director of the Youth Department, it became clear that the confined space is the most pressing issue for Friendly House right now. Ms. Delgado suggested that each department would need to have its own working space in different parts of the building, so that the working atmosphere could be more pleasant and structured for both the employees and those who are seeking help. Another prominent issue is the current lack of storage area in the current Friendly House; therefore, offices in the new facility should have some kind of shelving unit or closet to store documents and supplies, such as clothes, food and equipment.

The Youth Department of Friendly House has four major divisions: 1. The After School Program; 2. Teens Activities; 3. Sports and Recreation; 4. Summer Programs. For each division, Ms. Delgado gave us suggestions to improve the program within the future design.

Regarding the After School Program, which focuses on the children under the age of 16, there are between 50-70 children that attend each day. A homework room, computer room, multi-purpose room, cooking room and several bathrooms were all needed to support this program. The homework room needs to be a quiet area that allows children to concentrate on their work. Parents would have their own entrance and exit to pick up their children, but it was mentioned that this area should also be close to the gym. The computer room, which would be shared among all age groups, requires at least 10 working stations to allow children adequate access. The game room, which would be used for non-physical activities, would need to be spacious enough to host activities such as painting and board games. Similarly, the multipurpose room will serve as a group exercise area, where children can participate in physical fitness and dance classes. Also, a cooking classroom will be useful to conduct nutrition and baking classes, and should contain all electrical appliances rather than gas, for safety purposes. The last area mentioned is the bathrooms, which should be separated between the younger, after school group, and the teenagers. Boys and girls rooms both need at least 3 stalls and need to be easily accessible.

The area to be used for teens needs should be able to hold up to 100 people at any given time, although usually approximately 70 teens will be present. Ms. Delgado hoped for two classrooms and a quiet room in this area. The two classrooms should be separated so that one can be used as a gaming area, and the other one as a teen's lounge including couches, a pool table, and other furniture. The quiet room does not require an enormous amount of space, as it will be used for doing homework and watching movies.

The sports and recreation area, which includes the gym, should encompass a college size basketball court, with horizontal courts that could be separated by a divider. A running track around the top was mentioned as another possibility for this area. Ms. Delgado stressed that the floor needs be very durable wood rather than rubber, because it will be used for many different activities, such as basketball, volleyball and indoor soccer, and should be able to host sports all year long. It would also be convenient to add a storage room for various sporting equipment along with a glassed in office, which would allow volunteers to monitor the activities. Benches are also needed on one side of the basketball court for the players and bleachers on the other side for guests.

The summer program normally has more children that participate; between 100-150 kids per day. During the summer, both the after school and teen areas will be used for varying activities. Ms. Delgado's ideal vision includes a pool in the new building, but would be content with an outdoor sprinkler system that could be used to keep children cool in the hot summer months. As for outdoor sports, the master plan should integrate both a grass playing field and a paved court into the design. The playing field could be used for activities such as soccer and the paved court could be used for activities such as basketball or foursquare. In addition to playing fields, there should be excess green space that could be specified as a “picnic area” for children and families to enjoy.

Other than children’s’ activities, it was also mentioned that there should be a staff lounge, rest area, and conference room specifically for the summer program staff to make their jobs easier and more comfortable. The other benefit of having a conference room is that it could be rented out to various organizations when the summer program isn’t using it, which could be used as a source of income.

After interviewing current staff members, the total net area requested for each department was determined. A list of rooms was organized in Microsoft Excel based upon their intended use. When attempting to size each of the rooms, Architectural Engineering reference guides were used to estimate the different space requirements. The first was Ver Metric Handbook of Architectural Standards edited by Patricia Tutt and David Adler from Britain in 1979, and the other one was Architects Data edited by Neufert from Germany in 1970. These two books categorized space requirements by different types of commonly used spaces. Since Friendly House is a social service facility, the requirements were found in several different categories, such as office buildings, schools, etc..

Within these two books, the required area for each room is presented in terms of minimum area per person that will utilize the room. During the interviews with the Friendly House’s staffs, the maximum number of participants expected in each room was a focal point for this very reason. By multiplying the unit area by the number of people expected in the room, a minimum area for each room was determined. Due to the fact that these books were published in the 70's and the space requirements might have changed, several rooms on the WPI campus that have similar functions were also used as models and more space was added to the calculated area.

As another resource, there was an IQP completed by Sergio Salvatore in 2001 for Friendly House, which focused on building a new facility that would host all the current activities in larger spaces. In Appendix A, there are two lists; one which shows the areas for each room in Friendly House, and the other which details the areas of all the rooms in the new facility Salvatore had worked on. Thus, the team took these two lists and compared Salvatore's calculated areas with those formulated by the project group from the interview information. Table 1 shows the difference between his plan and the teams.

Table 1: Required Areas for Friendly House Services

Department	Present Area	Salvatore's Estimated Area	2011 FHP Estimated Area	Difference Between Salvatore's and 2011	Final Decided Area
Social Service Department					
1. Staff Area					
Total Staff Area	726	1415	2016	601	2089
2. Social Service Area					
Total Social Service area	0	1339	2510	1171	2618
Food Program					
Total Kitchen Storage	95	375	706	331	3400
Total Kitchen Area	405	540	2665	2125	
Youth Services Department					
Total Staff Area	255	858	1289	431	1383
1. After school program					
Total Youth Area	2139	3126	7302	4176	7302
2. Teen Activities					
Total Teen Area	0	264	2825	2561	2825
3. Sports and Recreation					
Total Indoor Recreation Area	2139	3390	10925	7535	10925
4. Summer Program					
Total Area for Afterschool Program (indoor)	2394	4248	11416	7168	22435
Other					
Administration Area		2769			2769
Bathroom Area		1595			1595
Circulation Area		1120			3109
Recreation/Educate		10874			10874
Storage		2561			2561
Total Indoor					51450

Most of the areas determined by the project team are larger in comparison to Salvatore's estimates, most likely due to the fact that Friendly House's needs have expanded in the past ten years and will continue to do so in the near future. The Friendly House community has been growing at a steady rate over recent years, and it is evident that if it continues to grow it will be nearly impossible to hold events of large capacity that Hargrove envisions. Friendly House has been searching for ways to prevent this from happening and to address this concern, the team designed all the rooms' to serve double the amount of participants that it currently does. However, there were some exceptions to this methodology. Some of the rooms in Salvatore's estimate were larger than those estimated by the team. Due to the fact that his study was a more in-depth analysis of the needs of not only the three major departments, but also the needs of the Friendly House as a whole. Therefore, in these cases, Salvatore's estimates were chosen to be included in the final design. The numbers in the last column of the table represent the area that was chosen.

In the final calculation, the square footage needed for the indoor portion of the facility was determined to be 51,450 ft^2, and outdoor portion will depend on how much land is leased from the City of Worcester to Friendly House. Appendix A shows the details of each room in the design, and the differences of each room between Salvatore's estimate and that of the project group.

Involvement by the City of Worcester

Throughout the project, the team knew it would be necessary to communicate effectively with the city of Worcester, and specifically Mayor Joseph O'Brien in order incorporate the city's vision with that of the Friendly House's into the master plan. Therefore, Professor Baller arranged a meeting with Mayor O'Brien and on October 24th, 2011, the team went to Worcester City Hall to give a presentation on the project to the Mayor and Councilor Philip Palmieri. Other than gathering information regarding the city's goals for the project, the presentation was intended to introduce the scope of the project, report on its progress, and discuss leasing possibilities for property owned by the City of Worcester that the Friendly House would like to acquire. Gordon Hargrove attended the presentation to help answer questions set forth by the Mayor regarding the leasing of property and the costs associated with the project.

William Baller, who is also a member of the Friendly House Board of Directors and Architect Dan Benoit were also in attendance to gain insight on the progression of the project and future work.

The beginning portion of the presentation was intended to give all parties an overview about the area requirements for the future Friendly House building. The team presented the table discussed in the previous section that showed details of space distribution and total area for the new facility. It was important to provide an explanation to all parties regarding how the final square footage was calculated based off of previous IQP reports and interviews with Friendly House staff members. Following this introduction, an aerial photo of the current Friendly House property was shown, along with the property boundary AutoCAD drawing so that the audience could get a sense of the several properties that are incorporated into the master plan. It was important to give a visual representation of the current Friendly House property, as well as the different lots to show both Hargrove and Mayor O'Brien which properties would need to be acquired or leased. The main topic of discussion concerned the property adjacent to the Friendly House lot, which Hargrove had hoped to get back from the city, who owns the property. The aerial photo showed that this property is heavily wooded and has dense vegetation, but with site improvements, it would be critical to the expansion of Friendly House and the park area. Hargrove mentioned that Friendly House had previously tried to develop this wooded area in the 60s, but due to lack of maintenance the vegetation soon grew back.

Next, the existing conditions plan was presented to provide an understanding of the drastic changes in elevation along the site. The alignments with their profiles were discussed in-depth, particularly the two alignments that run through the portion of the site which would eventually become a part of the recreational park. Since the alignments showed large changes of the elevation in this area, it was stressed that a great deal of excavation work and the installation of retaining walls would be required before proceeding with additional construction phases. O'Brien and Palmieri suggested that instead of spending ample time and money on performing site improvements, Friendly House could consider moving to another property, where its purchasing costs could be lower rather than improving the current site. Hargrove rebutted this idea however, stating that this new proposed property is significantly smaller than the current Friendly House property, and thus would not be big enough to satisfy all the activities that need to be incorporated into future design.

Next, the layout of future improvements for the Friendly House was shown. This site plan showed the location of new buildings, parking lots, and retention walls. During this portion of the presentation, O'Brien suggested that retention walls may not be necessary in some locations, since it is extremely expensive to construct retention walls and the park area could allow for slight elevation changes without mass excavation. It was also added that the park could be used as a preserved area for families to simply enjoy nature. It didn't necessarily need to include recreational fields or courts, but instead, many of the trees could remain to become part of the park design. O'Brien stated that he could get in contact with companies to begin clearing the site, but if some trees were kept and the excavation was kept to a minimum, it would greatly help reduce costs.

The most important goal of this presentation was for Hargrove to acquire rights to the property next to the current Friendly House. Since the city is not allowed to give away this land for free, the Mayor suggested that Friendly House buy the land from the city through an auction process. If the land in question is less than 2,000 square feet, the city would be permitted to set the bid price low for Friendly House. It is believed that there is not much interest in the property, therefore if it was placed up for auction, Friendly House should not have many competitors and can purchase the land at an inexpensive price. Following the conclusion of the meeting, it was decided that if this auction process is possible, Mayor O'Brien could proceed with selling the land to Friendly House.

Master Plan

The first portion of the project entailed laying out a master plan that could be broken up into several logical phases. With the knowledge of current site conditions and the needs of Friendly House and the City of Worcester, the team began developing a master plan that took all of these restrictions into consideration. Knowing these stipulations, the team discussed potential layouts that could incorporate all of the current and future needs. Additionally, with the help of architect Dan Benoit, the group was also able to integrate the low-income transitional housing complex that Hargrove had mentioned into the design of the site.

The first stage of this site design was recognizing the limitations of building on a site with drastic fluctuations of elevation. With this restriction in mind the team developed a layout that limited the quantity of excavation as much as possible in order to save money. This led to a design that would work with the changes of elevation by utilizing a tiered system. Working from the street level inwards, the site would consist of a series of tiered elevations that will be leveled off and connected to one another through the use of retaining walls and integrated stairs and ramps. This design allows for maximum land usage while reducing the cost of considerable excavation. Another benefit to this layout is the clear segregation of plots of land dedicated to distinct age groups for recreational activities. This tiered layout with necessary retaining walls is shown in Figure 15.

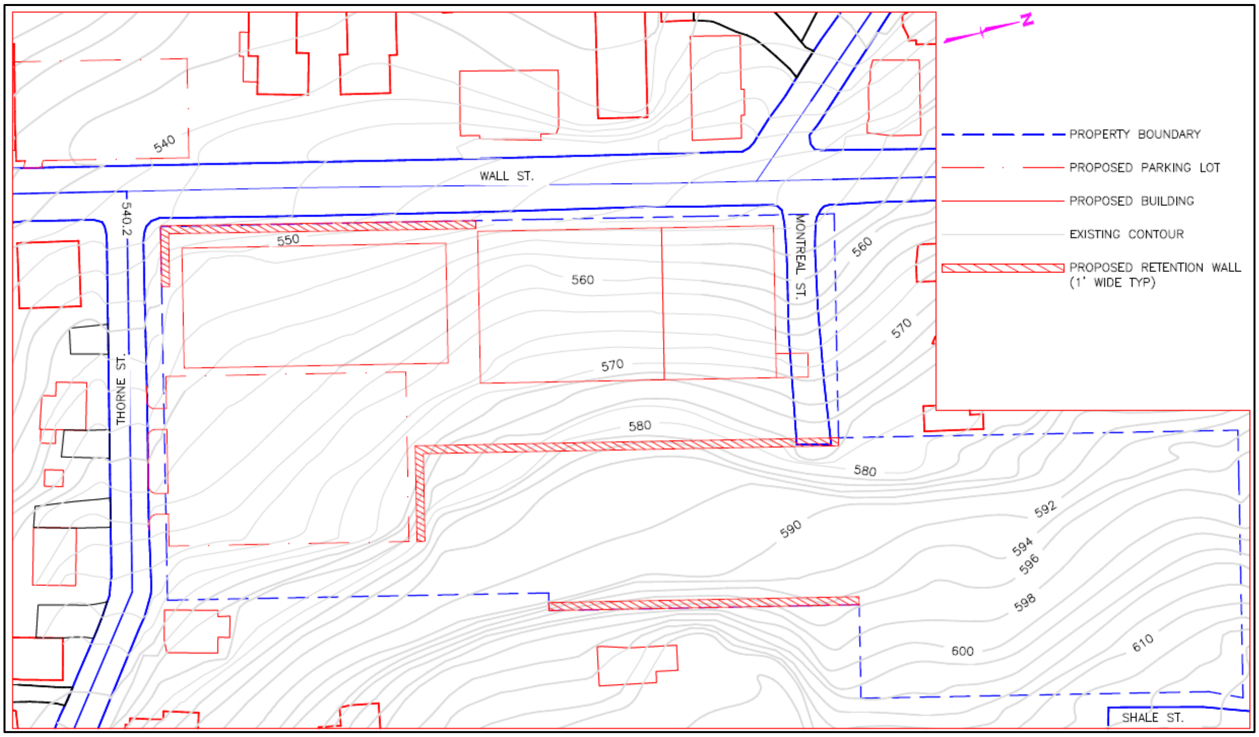

Figure 15: Master Plan: Site Improvements

The first tier of this layout is comprised of the main Friendly House building, the new gym facility and the housing complex along with a large parking lot and a small recreational area for young children and local residents. The second tier encompasses areas for older children and adults to utilize features such as a basketball court, playing field, playground equipment, and green space to relax and enjoy the natural environment. This layout allows children and adults of different ages to have their own areas, yet remain interconnected to one another and the main buildings of Friendly House.

With a preliminary layout in mind, the team began considering the square footage needed for these various activities by referring to what was learned through the meetings with Friendly House staff and Mayor O'Brien. After analyzing the square footage requirements for different departments the group established that a multipurpose gymnasium of 10,925 sq. feet was needed along with a 37,125 sq. foot main facility to encompass all of Friendly House's programs. With these numbers in mind, it was determined that the main facility should be built three stories tall to eliminate the footprint and save surface area for addition outdoor activities and parking. This building layout and representative sizing can be seen below in Figure 16.

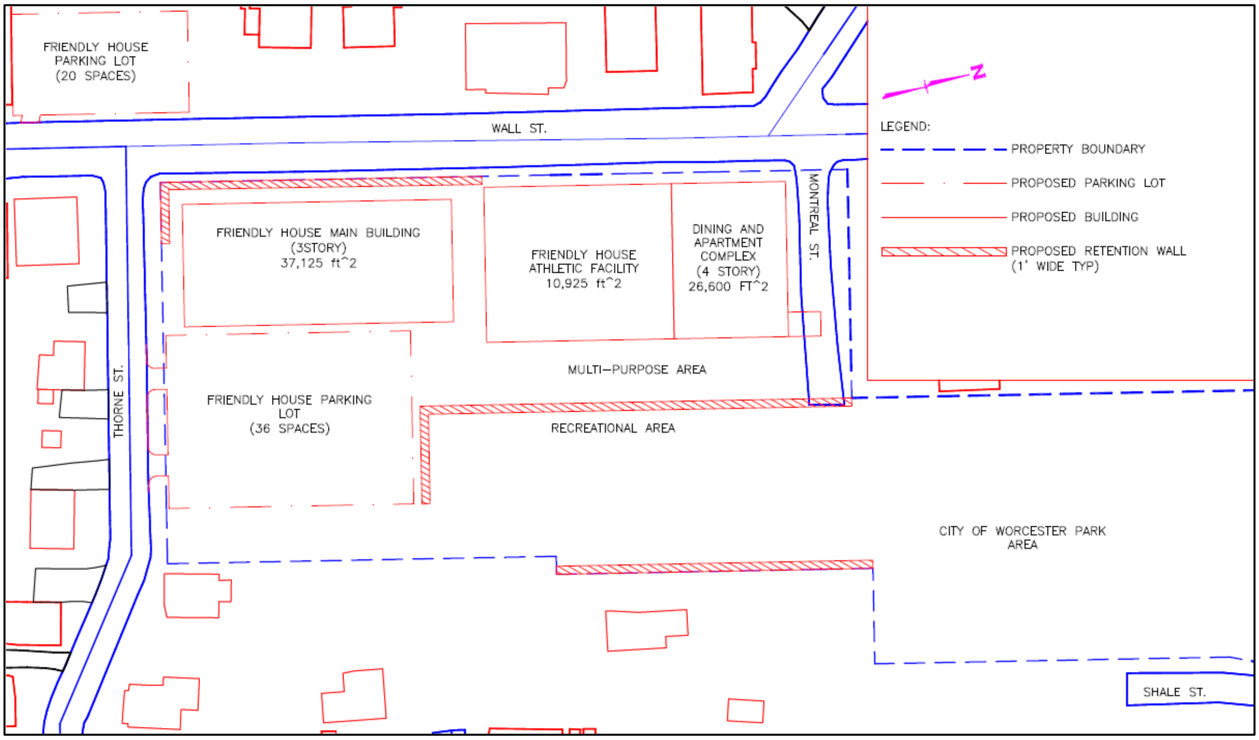

Figure 16: Master Plan Building Layouts

The project team decided to incorporate a permanent kitchen facility on the first floor of the previously mentioned housing complex. This decision was driven by the notion that the construction process will need to be broken down into several stages. To avoid the shut-down of food services and avoid additional costs, constructing a permanent commercial kitchen on the first floor of the apartment complex allows the food program to continue running efficiently while tearing down the current Friendly House facility.

While simultaneously designing a full site layout and a phasing plan, it was decided to construct the future apartment complex first. However, this new building will be constructed first as a temporary home to all essential Friendly House activities while construction of the new main facility is completed. This temporary shift of activities will allow the Friendly House to continuously operate their current programs, and once the main building is complete, all of the primary activities will shift back to the newly constructed building. After all activities are moved back to the main facility, the upper floors of the apartment complex will be converted to their original purpose of low-income housing for residents of Worcester.

To make this process more understandable, the following steps are outlined below:

Phase 1: Conduct all excavation, complete demolition of obtained properties on Montreal Street, construct necessary retaining walls, convert the lot across the street from the existing Friendly House into a permanent parking lot, and rehabilitate Shale Street as a fully functional access point for maintenance of the park.

Phase 2: Construct the housing complex adjacent to Montreal street with a complete, permanent kitchen on the first floor and open floor space to host temporary activities, construct the gymnasium which will be attached to the apartment complex, and construct an outdoor area behind the gymnasium for various activities.

Phase 3: Construct the main facility, convert the top three floors of the low-income housing complex into apartments, pave a permanent parking lot where the current lot exists, and complete the remaining outdoor areas with various playground equipment, a basketball court, and playing field. This sequential process should provide the Friendly House with a smooth transition process from the current facility to their future state of the art complex.

Following the completion of this design, the project team presented the idea to Hargrove and Architect Dan Benoit to see if it fully met their needs. The team presented the plans to them and accepted feedback on what may need to be changed. Among several issues discussed, was whether or not a new gym facility was needed or whether the gym could remain and be integrated into the newly-constructed facility. There were two reasons for this suggestion; one it would save money by preventing the need for additional construction of a gym, and two, the gym is fairly new and not necessarily in need of replacement. Another suggestion was to limit the size of the retention walls in hopes of again cutting the cost of this project.

With this said, it was decided that the region of land on the top tier of the design for recreational use would retain its current terrain would be used as a natural park. With this change along with the decision to keep the current athletic facility, much more room was created for the low-income, transitional housing complex. The additional space could now allow for a larger cafeteria to be incorporated into the housing complex design to host large functions such as holiday dinners. These deliberations moved the team in a new direction and therefor a revised master plan was created to accurately represent a more practical vision for the new Friendly House site.

A More Practical Master Plan

After receiving feedback from all the parties previously mentioned, the team proceeded to re-evaluate the master plan and create a new design that would be optimal for the Friendly House to meet all of their needs. This master plan revolves around the concept of keeping the old gym and connecting a newly constructed Friendly House facility. In addition it includes a low-income, transitional housing complex that is larger than in the previous master plan, housing a new industrial kitchen and cafeteria area. Including the layout of these buildings, the master plan itself can be broken up into several components that were carefully designed to satisfy the requirements of Friendly House, as well as any codes or regulations that may be involved. Thus, this section looks at the different components and provides explanations for the created designs.

Site Design

Since the elevations of the site grade change so drastically from one end to another, there was not much room for alterations of the retaining walls compared to the original plan. As seen in Figure 17, the retaining walls are still situated in a similar fashion to provide a tiered system of finish grade. The retention walls are situated throughout the site to not only provide a tiered setup that the Friendly House requested, but to also insure that there is no soil slippage or erosion that would cause destruction of the newly renovated site.

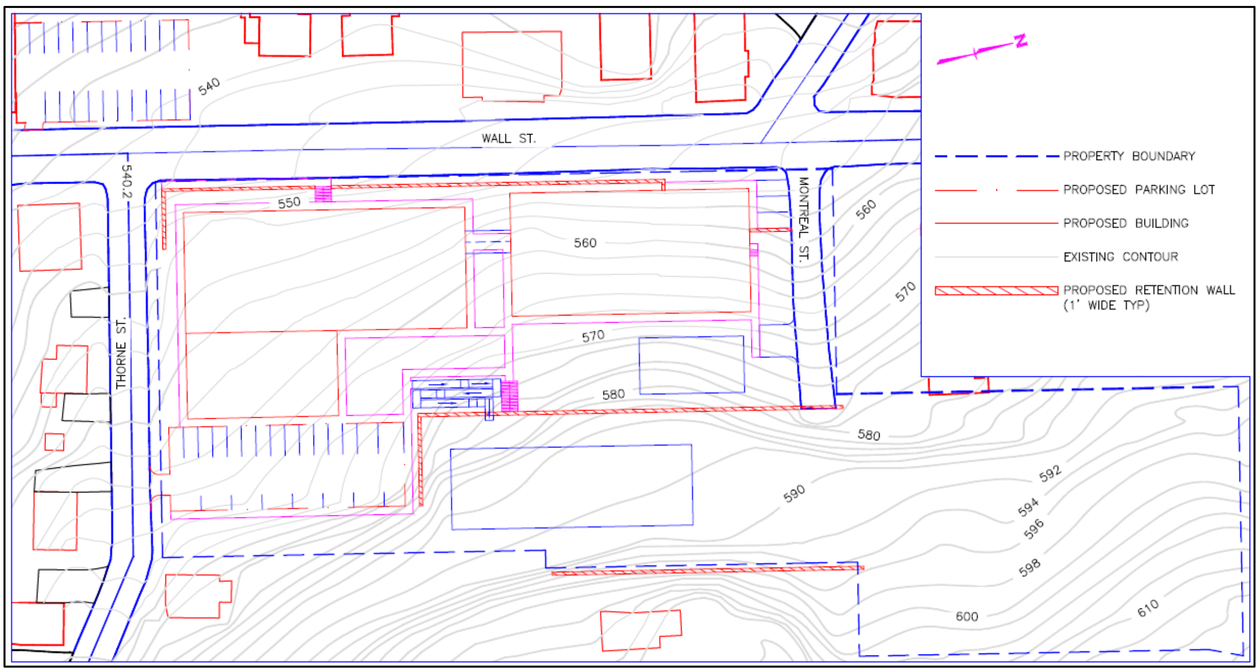

Figure 17: Modified Site-Work Master Plan

When looking at the elevations across the site in Figure 17, it can be observed that the current grade starts at an elevation of approximately 550' near the retention wall located parallel to Wall Street and ends with an elevation close to 570'. Therefore, it was decided by the project team that a proposed elevation of 560' would be the most practical elevation to use for the final design. This would alleviate the amount of material that will need to be transported to and from the site by choosing a proposed elevation that will balance cut and fill quantities. Starting from the beginning of the site near Thorne Street, it is seen in Figure 18 that an elevation of 560’ will produce a relatively balanced amount of cut/fill quantities across the site.

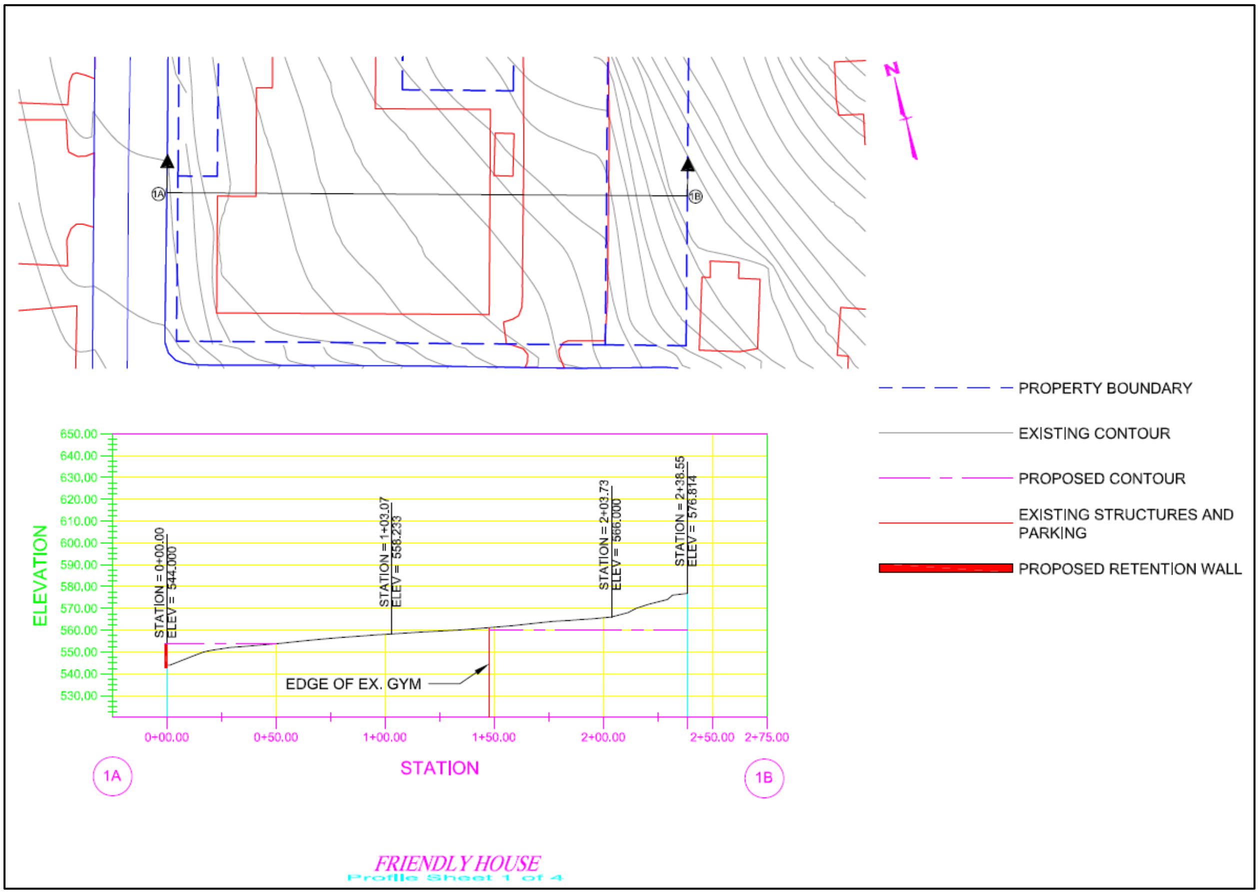

Figure 18: Profile of Existing vs. Proposed Surface, Front of Friendly House

The figure is able to show the difference between the existing surface, as described in previous sections, and the new surface at a new balanced elevation of 560’. In this section of the site, the excavation will need to extend along the entire width of the site because it is necessary to have a level surface throughout for the buildings and parking area. In addition, the profile shows the retaining wall along Wall Street and the edge of the existing gym that will remain, while the drawing above the profile shows precisely where it is located. It was important to show the edge of the gym in this instance because existing grade will stay as-is because there will be no construction done to the gym. As for the retention wall, it will be approximately 16' tall to accommodate the fill that is needed to reach the desired 560' elevation.

Moving North along the site, the second profile generated from the alignment located just North of the existing Friendly House facility, pictured in Figure 19, demonstrates a similar grading approach by leveling off the elevation at 560'.

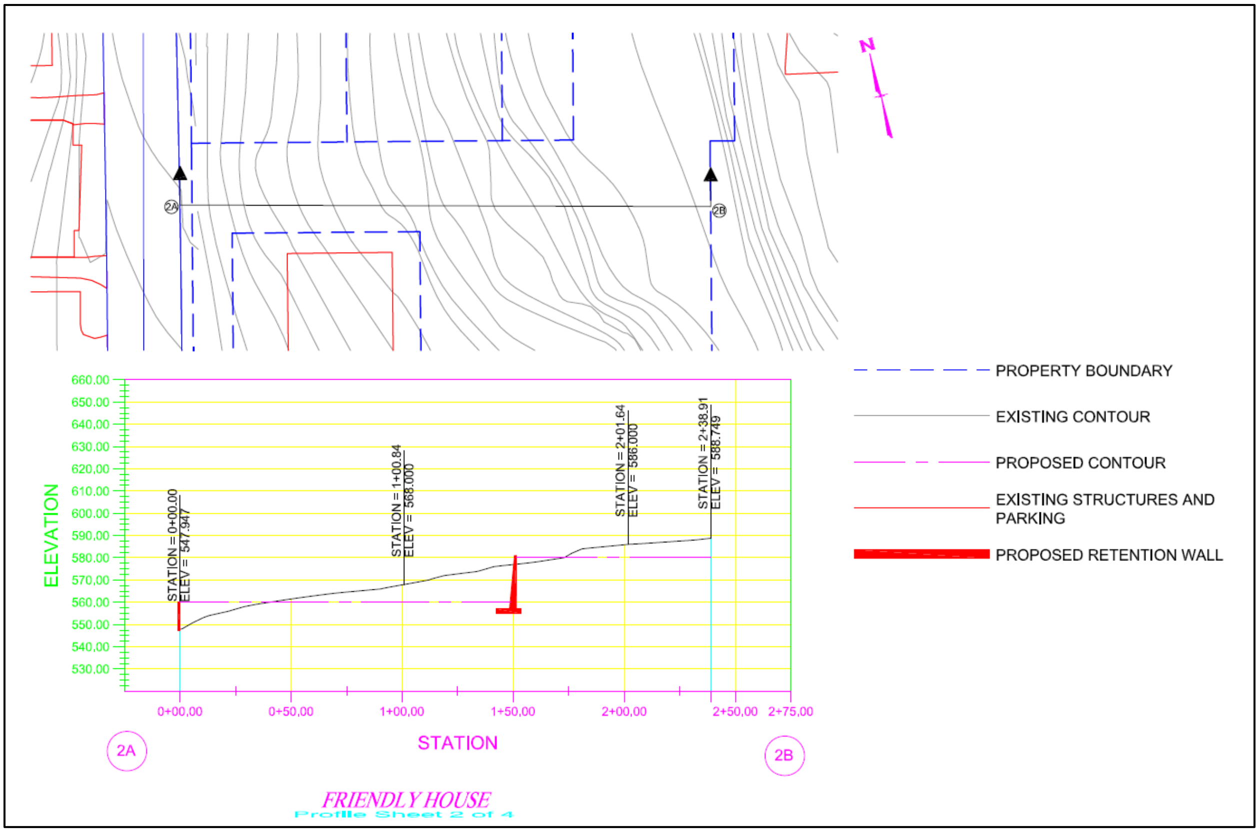

Figure 19: Existing vs. Proposed Surface, Mid Friendly House

This again balances the cut/fill quantities as much as possible, although it is evident that there will still be a considerable amount of cut generated at this cross section of the site. Also, since the site elevations increases so drastically, yet must be leveled, this section expresses what the two tier setup will look like on Friendly House property. Starting at the East end, the retaining wall will be similar to the wall on the previous cross section at 13' high and material will be filled in until it is level Westward. From there, grade will be leveled at 560' for roughly

150’ across the site, until it reaches the newly installed retaining wall. The retaining wall essentially provides a separation of the two tiers. Since at this cross section the property to the West is not considered land that will be transformed into a park, this surface will also need to be leveled off at an elevation of 580’. This minimizes the need for cutting material towards the West of this wall creating a level surface on both sides for recreational activities. However, the difference in leveled grade forces the retention wall to be over 20 feet tall, which will be extremely costly to build when site renovations are occurring.

Next, Figure 20 shows how the existing grade is affected by the proposed surface in the main area that the low-income transitional housing complex will be situated as well as the area that the City of Worcester hopes to utilize as park land.

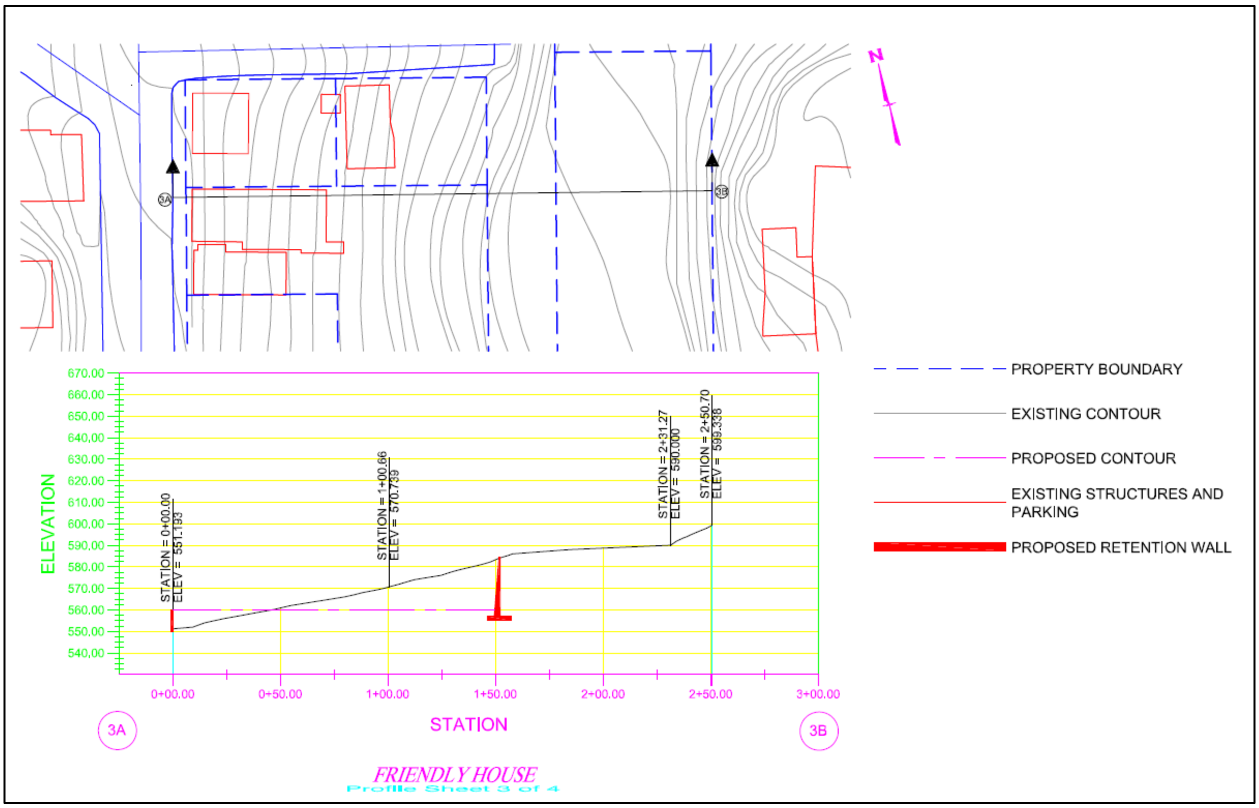

Figure 20: Existing vs. Proposed Surface, Montreal Street

Based off of suggestions mentioned earlier by the City of Worcester, the park land will remain at existing grade and serve as a place where community members can enjoy nature. As evident in the profile, the proposed elevation of 560' will only be graded between the two retention walls. In this case, the two retention walls enclose the Montreal Street properties, where the housing complex will be built, and will separate this area from the park land. However, since the park land will not be excavated, it once again creates an extraordinarily tall retention wall on the West side that will need to be approximately 25' tall, including the portion of it located below grade. This again will be an extremely expensive task, but is necessary if there is to be a tiered separation between Friendly House property and the park land. However, it is critical that the surface be leveled between the two retention walls so that the new housing building can be constructed.

Lastly, Figure 21 shows that the land along this alignment will not be graded to any particular elevation. The property boundaries to the East side show potential properties that the Friendly House could acquire in the future, but will not be utilized in this project because of economic constraints. Meanwhile, as mentioned, the park area will be a place to enjoy nature and thus its natural elevations will remain in-tact. The slope should remain untouched and thus, no retention walls are required to stabilize the soil and prevent corrosion. However, with the steep slope remaining, there should be additional considerations for collecting groundwater at the base of the slope near street level.

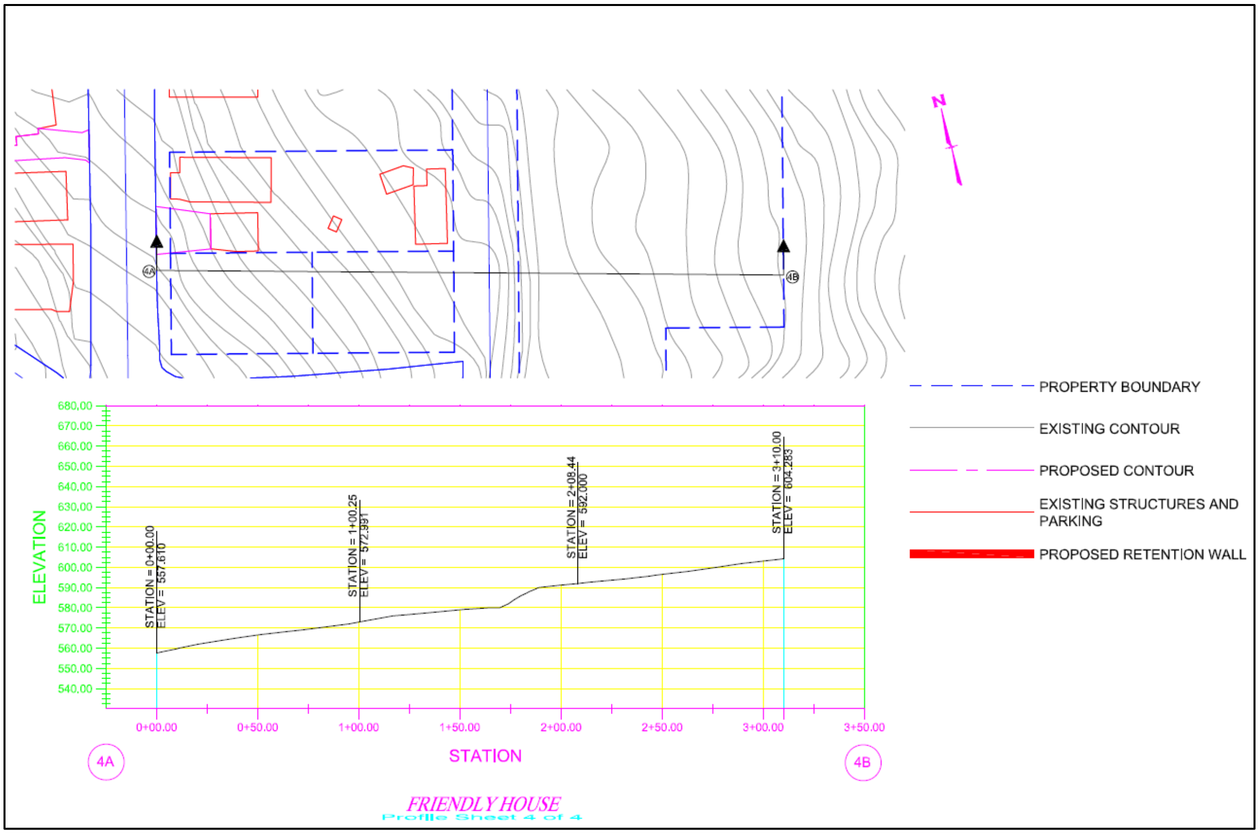

Figure 21: Existing vs. Proposed Surface, Shale Street

Building Layout

The orientation and size of the buildings for the modified master plan were designed with the appropriate amount of square footage to accommodate the Friendly House needs as well as provide a logical layout that would allow for the integration of such facilities into the existing site and structures. Figure 22 shows the new master plan with the layout of buildings, parking, walkways, stairs, and handicap-accessible ramps.

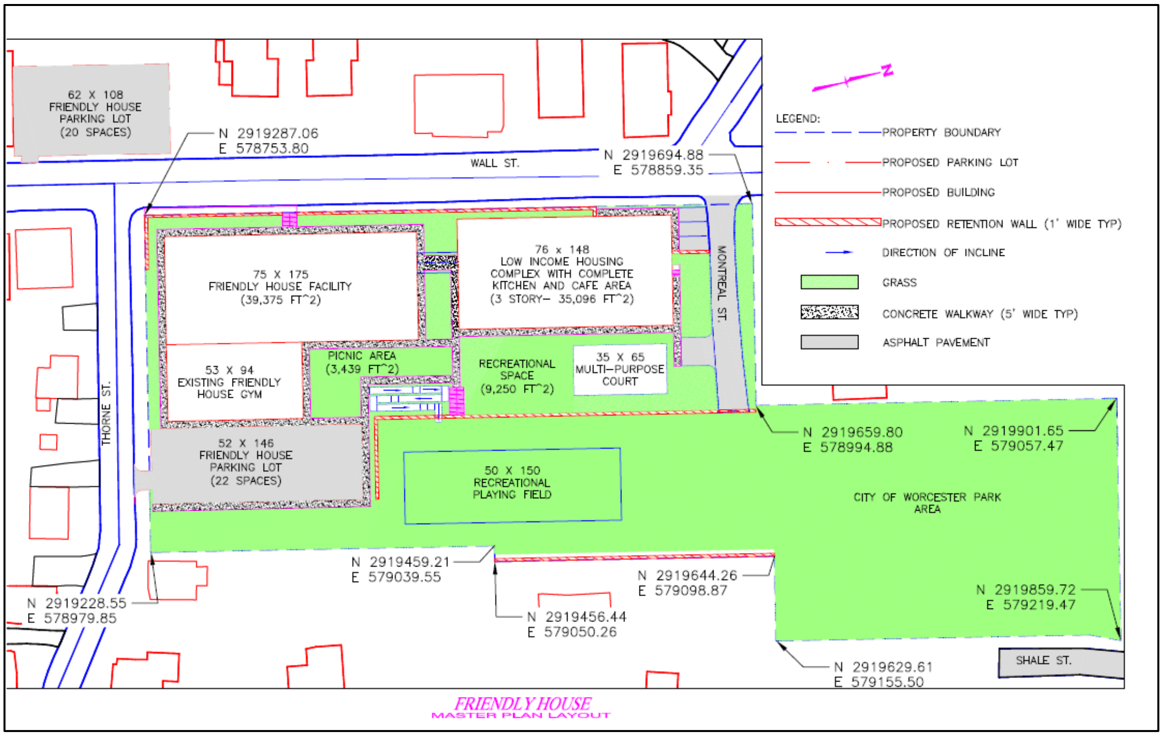

Figure 22: Revised Master Plan

Since it was determined that for the new master plan, the current Friendly House gym would remain in-tact, the layout of the new facilities needed to be orientated in such a way that integrated this existing component. The team decided that the new Friendly House facility would be situated much like the old one, except larger in size. Designing off the west end of the old gym, the new facility will extend to 20 feet from the roadway. This is approximately where there current Friendly House is and it will ensure that the new design does not encroach on the roadway more than the current building does. This also allows for walkways and a little bit of green space to exist on this end of the building, where the main entrance will be located. Once the dimensioning of the end of the building was determined to be approximately 75 feet, the length of the building was based upon the calculated totals of the required square footage of the area. In the original mater plan, the building was 3 stories and a total of 37,125 sq. feet to accommodate all of the Friendly House needs. However, the team concluded that the building in the new master plan would need to be slightly larger. The old master plan allotted space in the new gym facility that would now need to be located as a part of the main Friendly House facility since the exiting gym is remaining. It was calculated by the project team that the new facility should be approximately 39,375 square feet and remain a 3-story building. Therefore, in order to satisfy this square footage requirement, the length of the new facility is 175 feet, which gives it an overall dimension of 75 x 175 (times 3 stories for square footage).

Once the main facility was dimensioned and located correctly on the updated master plan, the team was able to position the low-income, transitional housing complex accordingly. This second building would consist of two stories of apartment housing, 1 floor with a permanent, fully-functional kitchen and cafeteria, and a lower level consisting of a small loading dock. After taking into account all of these purposes and additional Friendly House needs, as well as looking at architectural and structural requirements, a footprint of 75 x 145 resulting in a total of 33,875 square feet was deemed appropriate. Later sections of this report further detail the design and layout of the low-income, transitional housing. Other than square foot requirements from the Friendly House staff, the footprint of the complex was also constrained by Montreal Street on the North end. The team wanted there to be an adequate amount of space for parking and unloading, so the end of the building was set in order to do so. Another smaller constraint for the size of the complex was on the East end, where the team wanted enough green space for a multi-purpose court and grassy recreational area. A building width of 75 feet would allow for plenty of space for such activities to occur with extra space incorporated allowing for ease of mobility. As for the orientation of the building, the project team wanted the West side to remain in-line with the front of the new Friendly house complex and thus it was orientated approximately the same distance away from the roadway. This makes it a more eye-pleasing transition from the main

Friendly House facility to this complex. Also, since the new kitchen will be located on the ground-level floor, there will be a lot of personnel movement from this building to the main facility, so it was important to integrate these two building as smoothly as possible. On the South end, the building was orientated so that it was offset from the main facility by 29 feet. This created a separation of the different activities that would take place in this building compared to the main one. However, the distance between the two was kept relatively small, so that personnel from the kitchen could move back and forth from the main building. Keeping this gap short would also allow for an overhead roof system to be put in place so that human traffic will be covered during inclement weather conditions. Therefore, with the concern in mind, along with the many others discussed above, the complex was dimensioned and located in the most practical way possible for the Friendly House.

Parking

Throughout the interview process with Mr. Hargrove and the Friendly House staff, there was a consistent need to re-visit the parking requirements of the site. With the new main facility being much larger in size than the old, and the addition of the housing complex, it is undoubtedly required to add additional parking spaces to accommodate the large increase in traffic. In one interview session, Mr. Hargrove suggested that there be 50 total parking spaces for the staff and housing complex residents. Therefore, in an effort to add more parking, the team first expanded the current parking lot as much as possible to allow for the maximum amount of spaces. Seen below in Figure 23, the current lot was expanded to 52 x 146 feet, which gives adequate space for approximately 22 spaces. The lot's main restrictions for its size were the existing gym to the West and heavy shale to the East that would make additional excavation too costly.

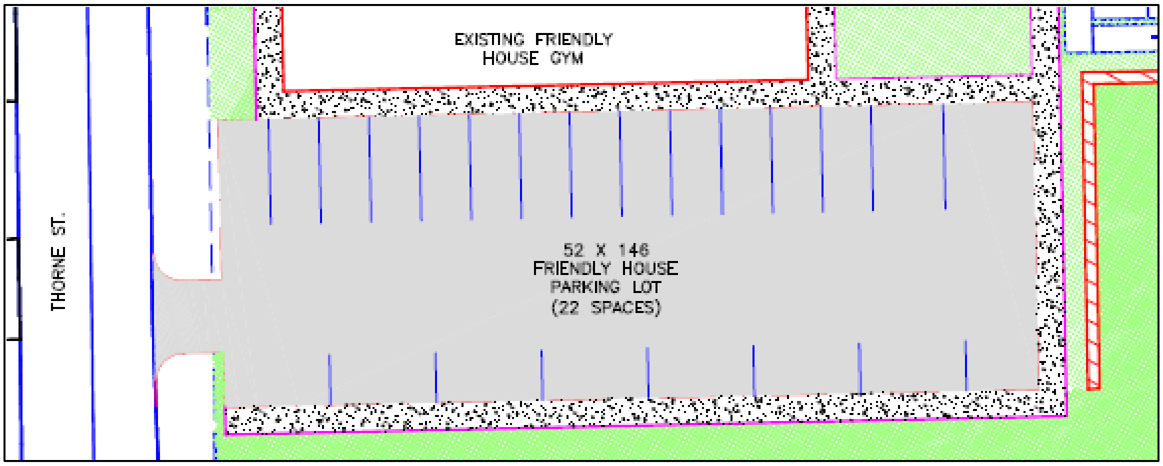

Figure 23: Parking Next to Existing Gym

This main parking lot incorporates a design of parking spacing placed at 0 and 90 degree angles. According to parking standard published in Colorado, the spaces at a 90 degree angle are approximately 9 feet wide by 19 feet long for a standard space (*Parking Standards*, 2011). This gave space for 13 regular spaces along the West side of the lot, with the addition of three handicapped spaces that are required by the standards. In accordance with these standards, these handicapped parking spots need to be specified as handicapped with clear signage that shows the symbol of accessibility. In addition, it is required that 1 in 8 handicapped spots are van accessible and should be a minimum width of 13 feet. The parking lot on the master plan shows two of these van-accessible spots. On the East side of the lot, there are 7 more spots situated at a 0 degree angle, parallel with West walkway. Again looking at the standards, these spaces are required to be 23 feet long and 9 feet wide.

Next, as seen in both the original and revised master plans, the property situated across Wall Street is converted to an additional parking lot. Utilizing this property to its full extents, as seen in Figure 24, the team was able to add 20 parking spaces in the 6,696 square feet of land.

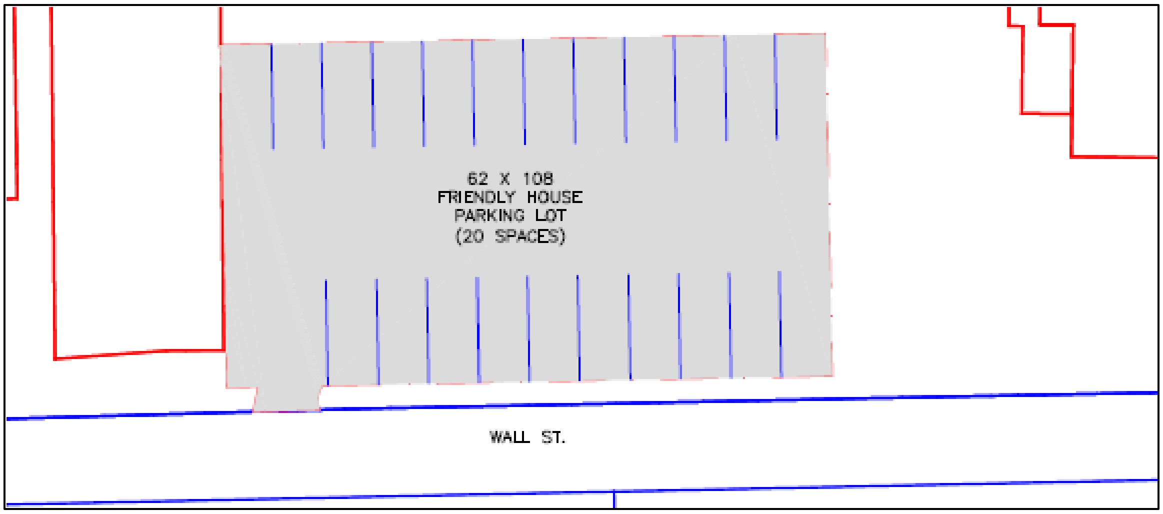

Figure 24: New Parking Lot Across Wall Street

As previously mentioned the conversion of this land is dependent on Friendly House gaining approval that there is not any environmentally-toxic groundwater in the soil on site. It can also be seen that all of the parking spaces in this lot should be orientated at a 90 degree angle to maximize the number of spaces. These parking spaces will be able to provide convenient access for clientele to the main Friendly House facility located directly across the street.

Finally, in addition to these two lots, the team took into consideration the amount of street-side parking that is available for people to use. Although it is not indicated on the master plan, there is a considerable amount of parking along Wall Street and Thorne Street. Thus, Friendly House should work with the city to ensure that this road-side parking is available to clientele when need-be. The team does not anticipate that road-side parking will need to be utilized on a daily basis, but it will be especially useful when Friendly House holds larger sized events, like holiday dinners.

Walkways and Stairs

Throughout the site, walkways and stairs have been designed by the team to promote the greatest amount of convenient mobility for clientele, while trying to limit the amount of construction material that will be needed. Walkways were designed to be 5 feet wide and are situated in such a way that allows foot traffic to flow smoothly from the parking lots to the facilities, and to allow personnel to walk from building to building. In addition there is a 10 foot wide walkway that provides easy access from the main facility to the new, fully functional kitchen. The team designed this walkway to be wider in anticipation of increased traffic flow and took into consideration that equipment such as food carts may need to be mobilized from the kitchen to the main building. Overall, including walkways of both widths, there is a total area of 8,732 square feet throughout the site.

To provide mobility to buildings and access to them, there are 3 main sets of stairs. There are stairs located at the main entrance of the Friendly House facility which are 10 feet wide. These stairs provide mobility in both directions because there will likely be a high amount of foot traffic. Meanwhile, the stairs at the North End of the apartment complex that allows direct access to the first level of the apartment housing are only 5 feet because there will likely be less traffic in this area. Finally, there is another wide set of stairs located at the retaining wall that separates the first tier from the second tier. This will allow users to have easy access to the second level recreational area.

Handicap Accessibility

Aside from the handicap parking spaces, the site is also designed to accommodate handicap clientele mobility to the second tier of recreational space. Thus there is a handicap ramp that begins on the first tier near the North end of the main parking lot and proceeds up to the second-tier, recreational area. The ramp itself was designed to meet *Handicap Ramp Design and Construction Guidelines* (2006) and therefore the design of the ramp was restricted in certain ways. For handicap ramps, the guidelines specify that there can only be a 1:12 slope (8.3 %) and there must be a landing of at least 8 feet by 5 feet for every 30 feet of ramp. Therefore, in order for the ramp to reach the height of the second tier, the total length is approximately 120 feet long. Additionally, to agree with standards, the ramp should be constructed 42 inches wide to allow easy mobility. Following these standards in the design will keep the ramp in compliance with all codes as well as provide convenient access for the handicapped to the second tier.

Recreational Space

The final component of the revised master plan involves the recreational space that will be utilized by different age groups. Aside from the park that will be managed by the City of Worcester, there are two major recreational areas incorporated into the master plan. The first space is located between the retaining walls that separate the tiers and the main Friendly House building and housing complex. As seen on the drawing, there is a small section located to the North of the existing gym that is roughly 3,439 square feet. This area is intended to provide a smaller, isolated area that could be used primarily as a picnic area for families. On the other side of the North walkway there is additional recreational space, consisting of 9,250 square feet of green space and a 35 x 65 foot multi-purpose sports court. This area of the site can be used for kids to participate in activities such as basketball on the multi-purpose court and as a green space to participate in other active games. Finally, located on the second tier, is more green space and a 50 x 150 foot playing field. In order to provide adequate conditions the playing field will need to be leveled off at a consistent grade. The team recognizes that doing so will increase costs by a significant amount, but if Friendly House needs a playing field this is the most practical location. Outside of the playing field, there will then be a smooth transition to the City's park, which will eventually turn into existing grade conditions.

Design of a Transitional Housing Complex

The most critical component of the Friendly House master plan is the new low-income transitional housing complex that will be built before the main facility. This building will allow Friendly House's food service program to significantly expand in order to accommodate its growth and future plans for providing meals to needy residents of Worcester. This will be completed by designing a new state-of-the-art kitchen and café area on the first level. In addition, the complex will allow Friendly House's programs to remain operational during the construction process by designing the top-two stories in such a way that will allow these programs to function until they can be relocated back in the main facility. Upon completion of the main facility, these top two floors will be transformed into low income housing apartments that can serve as a source of income to the Friendly House as it completes the project and beyond. This section of the report thoroughly explains the research and design considerations that were put into both the architectural and structural layout so that the facility could meet its desired purpose upon completion. The section also provides calculations and explanations pertaining to the sizing of the building's columns, beams and girders in order to confirm the structural integrity as well as provide suggestions for the most economical design. Finally, it looks at possibilities for making the housing complex an energy conscious design by integrating a green roof into the final design of the building.

Space Requirements

Knowing the Friendly House needs a building that will not only be home to a new commercial kitchen, but also serve as a temporary facility and eventually become low-income transitional housing; the team focused on designing a building that would fluidly accommodate all these requirements. The first step in doing so was to determine how much space would be required for a building of this type. Our team reverted back to the space requirements originally deemed necessary for the Friendly House's new kitchen and found that approximately 6,600square feet would be necessary. In addition to a commercial kitchen, Mr. Hargrove suggested the idea of adding a cafeteria to serve as an eating space for not only the children, but also for large functions such as Thanksgiving Dinner. To serve such a function, the team looked to the Architect's Studio Companion book for guidance. With this reference in mind, the team adjusted to what was thought to be accurate for the Friendly House's activities and determined that approximately 7,000 square feet would be appropriate. With these ideas in mind it was determined that a footprint of 12,000square feet would be necessary. In addition, a loading area must be incorporated to accommodate large deliveries while working with the steep slopes previously discussed. The team met with architect Dan Benoit to discuss possible options and gain an experienced professional's point of view. Deliberations led to the idea of having a small reception area and loading dock on the street level, with the cafeteria and kitchen on a much larger second level. This would allow delivery vehicles to have easy access to goods coming in and out of the kitchen facility, while minimizing the necessary excavation. This design however means that an elevator will be necessary to transport the goods from street level up to the kitchen. Table 2 summarizes all assigned areas in comparison to the overall building dimension as determined by preliminary analysis and The Architect's Studio Companion manual.

Table 2: Transitional Building Square Footage Requirements

	Suggested Square Feet	Designed Square Feet	% of Building Area
Kitchen	2,665	3,825	11.13%
Cafeteria	N/A	7,200	20.96%
Loading Dock	700	1,250	3.64%
Two-Bedroom Apartment	1,000	1,188 x 12	41.50%
Three-Bedroom Apartment	1,200	1,287 x 4	14.99%

With preliminary sizing complete for the first and second floors, the team needed to ensure that this layout would accommodate the eventual transitional housing that would reside on the above floors. Mr. Benoit was again called upon for professional advice on best practices in designing apartments. He provided the team with a couple different floor plans that he has used on previous projects to be used as templates. The team evaluated several floor plans and determined that based upon the building's footprint, two floors of apartments would adequately serve the needs of the Friendly House and provide an adequate amount of revenue.

With building size and shape determined, detailed floor plans became a priority. The team started designing the two floors of apartments because their wall layout will dictate the structural layout of the first two floors. By combining the layouts provided by Mr. Benoit, and the restrictions of the building size, our team began to layout the apartments. Knowing that this building needed to be long and narrow in order to minimize excavation, it was obvious that this building must have a double loaded corridor in which the apartment layout will be mirrored on both sides of a central hallway. This central hallway will incorporate matching stairwells on each end providing two ways of egress in case of emergency. Using *Revit Architecture*, an Autodesk software geared toward architectural layouts and rendering, the floor plans were completed. In hopes of maximizing the usage of space, and keeping in mind the average square footage of a typical apartment, it was determined that each floor should include six, two-bedroom apartments and two, three-bedroom apartments, resulting in a total of 16 apartments for rent. The other upside to a double loaded corridor with four apartments on each side is that the four apartments on each side of the corridor can also be mirrored allowing for easier construction and utility hookup. The bedrooms will line up making framing easier, while the kitchenettes and bathrooms will lie adjacent to one another allowing for easier installation of necessary plumbing and gas fixtures. An example of this type of layout can be seen in Figure 25 and additional detail drawings can be seen in Appendix C.

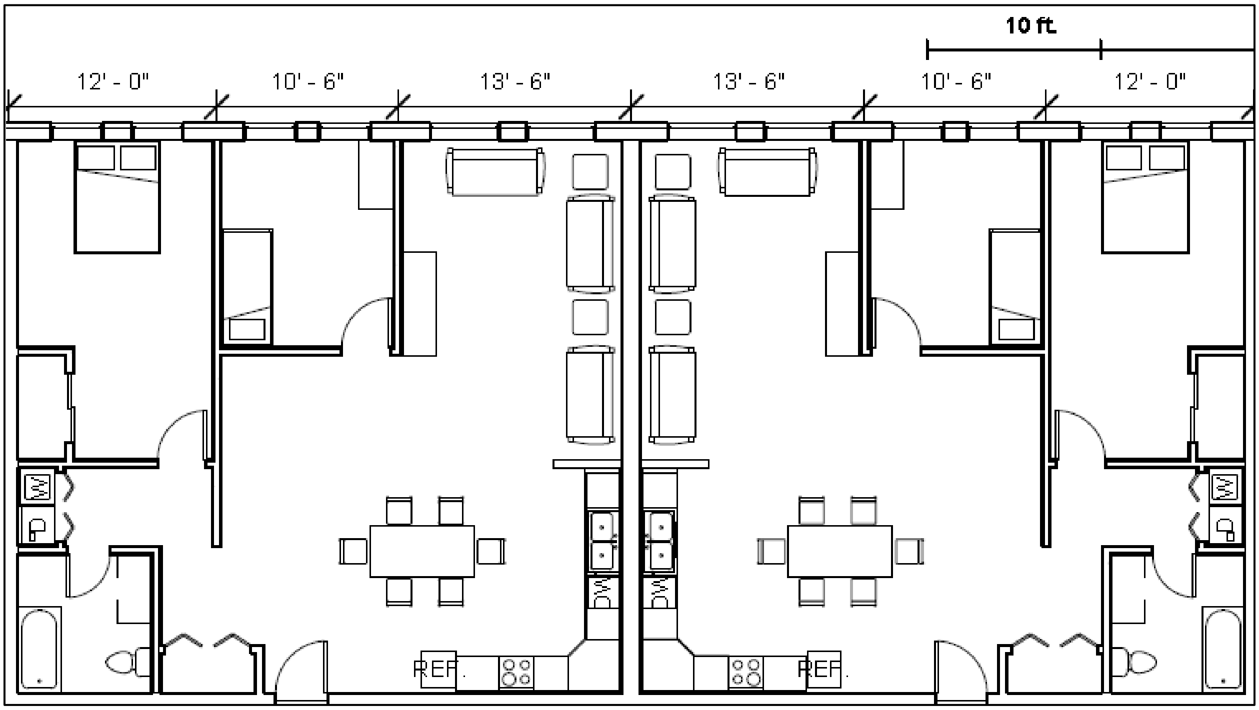

Figure 25: General Apartment Layout

It is also desirable that the apartments are as spacious as possible given the limited square footage allotted. While assuring privacy in the bedrooms and bathrooms, it is also important to maximize the number of windows allowing natural sunlight to enter the rooms. With all of these considerations, this layout proved to be the most efficient.

Compliance with Local Zoning Requirements

However, before in depth designing was completed, it was important to make sure that this building would comply with local zoning codes. Mr. Benoit was contacted for guidance on local zoning codes that were of importance at this point in the project. He pointed the team to the district zoning requirements of the City of Worcester and specifically district RG-5, in which Friendly House resides. The first thing to check was the permitted uses by district to see if such a building was even allowed. It was found that in district RG-5 a recreational/service facility (non-profit) is allowed with a special permit and a low-rise, multi-family dwelling is also allowed (*Zoning Ordinance*, 2011). From there it was important to assure that the proposed building size is considered low-rise and did not exceed applicable FAR regulations. The district permitted dimensions for a multi-family, low-rise residential building allows for 3+ stories with a maximum height of 45feet. It was also determined that for such a building there must be a minimum lot area of 5,000 square feet for the first unit and an additional 1,000 square feet for each additional unit. This means that a total lot area of 20,000 square feet is necessary for this building. The lot dimensions provided on the ownership plan previously shown prove that the lot does indeed meet these requirements.

In addition to total lot size, there are also requirements that stipulate frontage and size of the yard surrounding the building. In district RG-5, a multi-family, low-rise dwelling requires 50feet of frontage for the first unit and an additional 5feet for each additional unit. This would mean that the proposed building requires a frontage of 125feet or greater. The proposed building has a frontage of 175feet which meets the requirements. The next factor was to determine if the proposed building was placed on the lot appropriately, meeting applicable yard requirements. Local regulations call for 10 feet of yard on both sides of the building and 15 feet in the front and back. The current location of the proposed building meets all of these requirements except for the front yard. However, our team feels that the Friendly House get can around this restriction by applying for variance. The Friendly House can make a case that not only are they a non-profit facility, but also that there is a clause that allows variance when matching the surroundings. All of the nearby buildings along the east side of Wall Street are less than 15 feet from the street. Therefore, Friendly House will likely be granted variance, especially since it needs to be so close to the road to allow for easy loading and unloading on the street level floor.

The only other important factor to consider is the required parking space for this facility. By law, there must be two parking sports for each dwelling unit meaning that 32 parking spots are needed. In addition, there must be 1 parking spot per four people accommodated in the cafeteria. With this requirement, and the current site layout, there are not enough parking spots. However, Friendly House may be able to apply for variance on this as well. The two points of argument would be that one, the dwelling units are to be rented to low-income families that may not have two cars each, and two, only approximately 4 times a year will the cafeteria be full. These two factors, in addition to the parking along the street may be enough for the city to grant variance of some sort. Figure 26 shows the proposed building footprint and its corresponding parcel of land, illustrating compliance with the applicable zoning requirements.

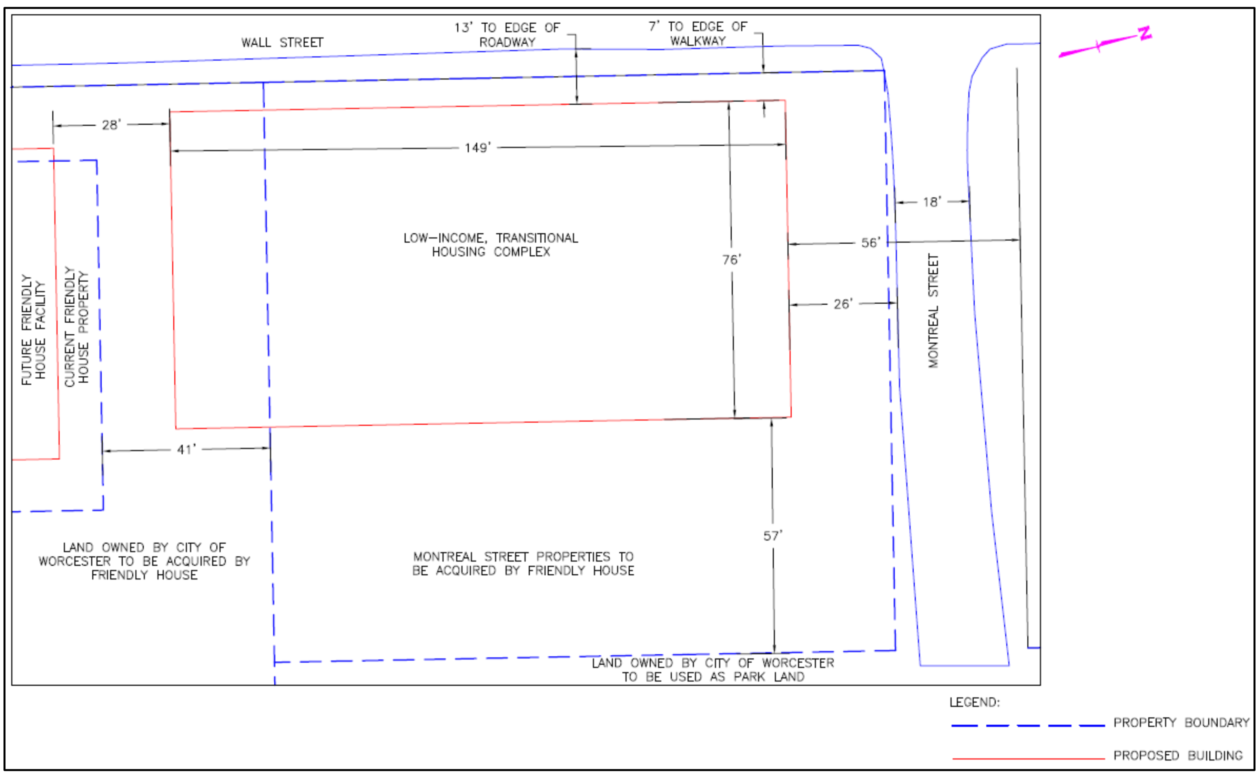

Figure 26: Parcel Boundaries and Building Setbacks

Criteria for the Structural Design

With nearly all of the district regulations met by the preliminary design, efforts turned back to more detailed design of the building. Before floor plans could be finalized, the team needed to evaluate the structural components of the proposed building. The first step was to choose the structural material to be used that would not only support all of the applied live and dead loads, but also prove to be the most economical. Stone masonry, although easy to procure, is very difficult to handle and is labor intensive, therefore eliminating it as an option for this building. The option of using wood for this structure was brought up because of its economic value and ease of construction. However, due to the large loads of this building, and the need for fireproofing with an industrial kitchen, wood was deemed inappropriate for use in this building. Precast concrete would be an ideal material to use in this project due to its high compressive stress and fireproofing. It would also allow for a two-way concrete slab, meaning the floors could be thinner and reduce the overall height of the building. However, the cost of manufacturing and shipping precast concrete is very high so the team looked into where the nearest manufacturer is located. Unfortunately there are no manufacturers close by, eliminating precast concrete as an option. Steel, the most common building material, seemed to be the best option when trying to limit cost and labor while maintaining structural integrity. Steel is relatively easy to construct, very durable, and cost effective. For these reasons, the group decided to design the building with steel as the main component with concrete on deck for the floors and concrete masonry units for the sheer walls.

With the structural components decided upon, the next step was to design the structural layout of the building, determine placement of columns, and decide on structural bay shape. The difficult part is that column placement is restrained by the floor layout, particularly that of the apartments. The positioning of columns is important for functional ability and aesthetics, as one would not want a column in the middle of a room or hallway. Careful placement will give the residents a more convenient and comfortable living environment. Besides comfort and practicability, column placement also determines the shape of the structural bays. A structural bay is normally rectangular in shape because it is the most economical way according to structural engineers' experiences over the years. The most economical ratio between the length and width of the bay is between 1.3 and 1.5, per professional advice. Besides economic benefit, column spacing is also important because columns that support the same bay should not be placed too far apart from each other, otherwise the heights and weights of girders and beams in between will increase significantly, which directly affects the thickness of each floor.

The group began exploring possible column layouts that would work with the architectural floor layout previously designed. The result was three different layouts which were compared and the more applicable and economical design was found. In the first scenario, columns were placed in the partition walls of the apartments. This resulted in structural bays that were square in shape, which were applicable, but not economical. More steel would be used and more labor force would be required to connect all the beams and girders, therefore this scenario was abandoned with Professor Pietroforte's approval. This layout can be seen in Figure 27.

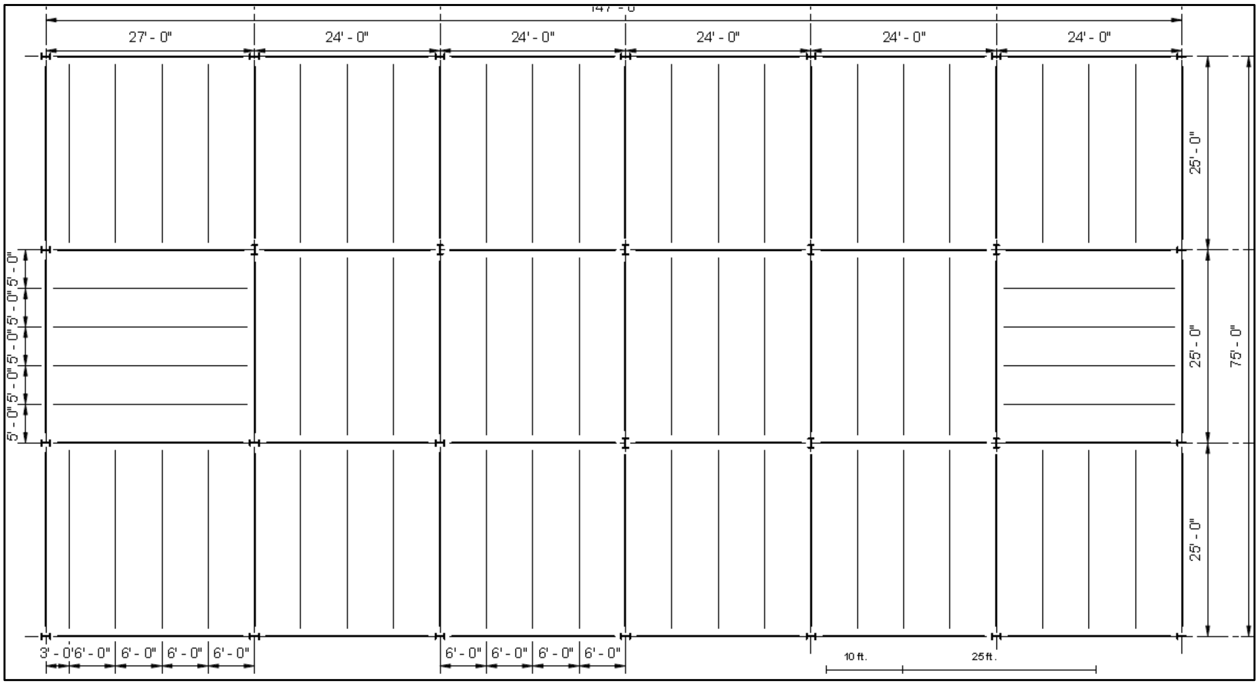

Figure 27: Preliminary Structural Layout #1

After discussing options with Professor Pietroforte, it was suggested that the columns be placed within the exterior walls and the walls between apartments and the corridor. This way, all the structural bays would be rectangular shaped, and all girders would be hidden in the walls. However, the structural bays below the corridor were very small, and this type of layout might require more materials and formwork cost. Another downside of this design is that the columns extend all the way down into the cafeteria and kitchen on the first floor, which is supposed to be open floor space. There would be two rows of columns 8 feet apart making it very inconvenient to those cooking and eating in this space. Therefore this design was also ruled out. This layout can be seen in Figure 28.

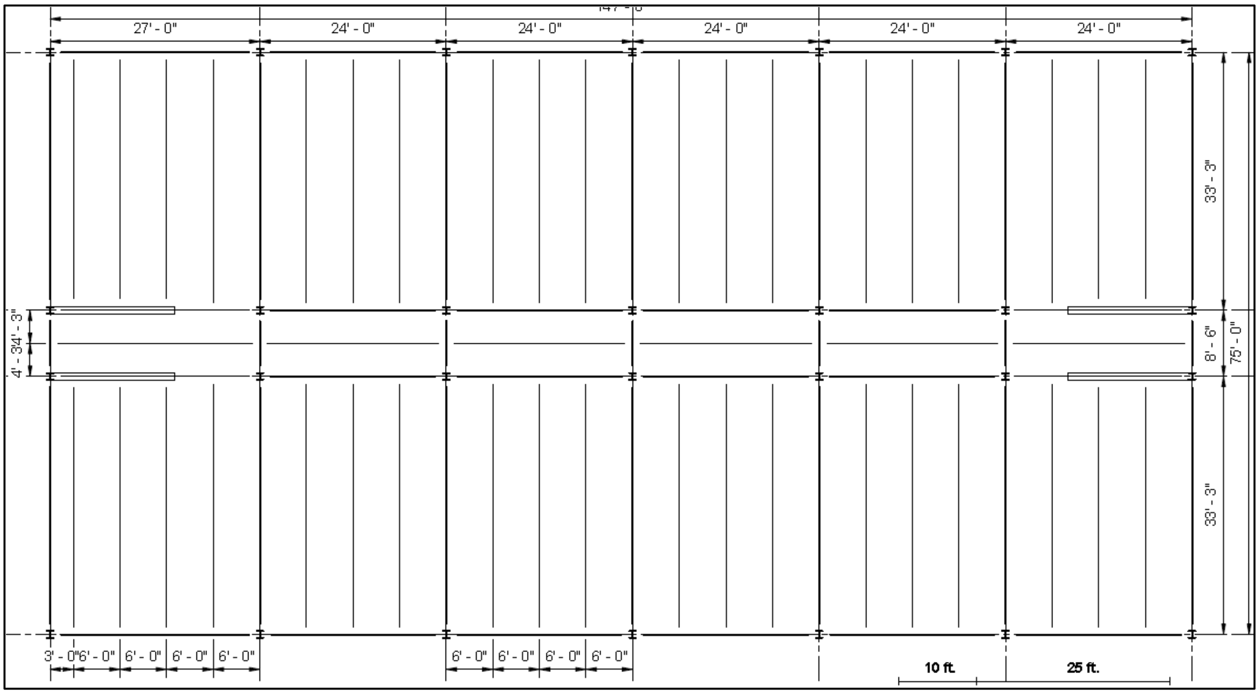

Figure 28: Preliminary Structural Layout #2

The third scenario for the structure is a compromise of the previous designs with all of the structural bays being rectangular in shape with an economical design ration between 1.3 and 1.5. This design resulted in readjustments to the apartment floor layout, but the adjustments were not significant. There were a few rooms that got shifted or resized but the general layout remained the same. This structural bay layout can be seen in Figure 29 and additional structural drawings can be seen in Appendix C.

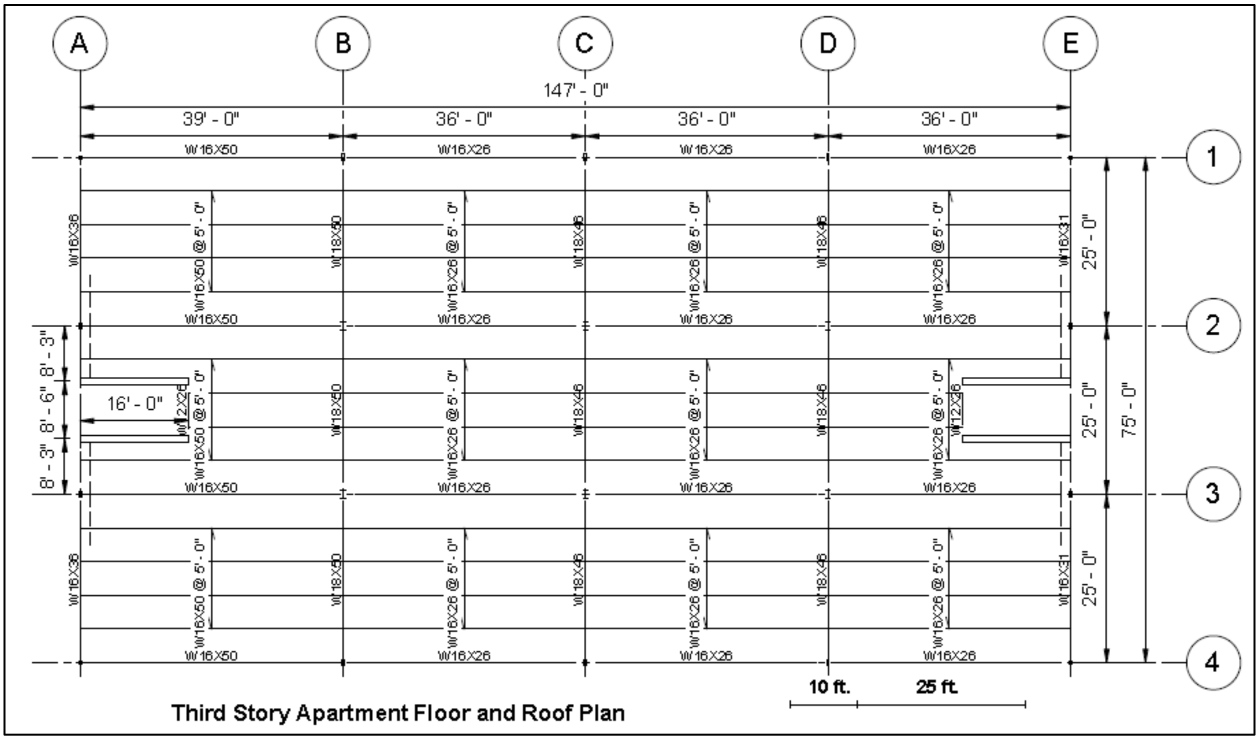

Figure 29: Final Structural Design Layout

With this layout approved by the project advisor, details were added, such as CMU shear walls, side brace steel, square footings, and retaining walls in the loading area, which can all be seen above. The entire structural layout was then approved by a structural professor at WPI.

The most important part of the structural design is sizing each element in the structure. Failure of any part of the building can be catastrophic to the residents, owner and designers. The knowledge obtained from steel structure design classes was used to sizes of all the beams, girders and columns. Calculations were conducted and verified by a structural professor. The first step in sizing the structural components is to determine the loads which the building will have to withstand. Table 3 shows the loads used in the calculations and their placement.

Table 3: Structural Load Values

Type of load	Loads (psf)*
Roof	
Dead load total	**47.10**
Soil[1]	30.10
Plants	2.00
Conventional Roof	15.00
Live load	**20.00**
Snow Load	**55.00**
Floor	
Dead load total	**55.00**
Concrete/deck[2]	35.00
MEP	5.00
Ceiling	3.00
Partition	12.00
Apartment live load	**40.00**

1. Soil type: Stalite Extensive Mix. Saturated Density: 91 lb/ft^3. Depth of soil: 4 inches.
Unit weight: 91 lb/ft^3 x (4 in. / 12) = 30.1 lb/ft^2
2. Light weight concrete on steel deck.
*Some of the loads were assumptions, and require further detailed analysis.

LRFD (Load Resistance Factor Design) is the AISC Design approach

Factored loads for roof and floor are listed below:

Roof: $1.2D + 1.6(L_r / S / R) + (0.5L / 0.8W) = 1.2*47.1 + 1.6*55 = 144.52\,psf$

Floor: $1.2D + 1.6L + 0.5(L_r / S / R) = 1.2*55 + 1.6*40 = 130\,psf$

During construction:

D = decking weight + beam weight

L = wet concrete weight + service load

As the loading conditions showed in the above chart, the value of distributed loads on the roof is relatively close to the ones on each floor, therefore the roof will use the same sizes beams and girders as the floors. In the structural layout, there are two different size structural bays, several with a length of 36 feet and the one with a length of 39 feet. These different bays will use different beam sizes but were calculated using the same formulas.

One thing that must be considered when sizing the beams is whether or not there will be shoring. Shoring requires extra supports during construction to prevent the beams from collapsing when the concrete slab is still wet. Using this method, beam sizes will be decreased, which means less material costs, but placing and taking off supports will extend construction time, and increase labor costs. The unshored method does not require any supports during construction; however, the only way to have the beams take all the loads without failing is to increase the depth. There have been cases that structures fail during construction because structural engineers did not consider that the loadings in construction were larger. The reason for this is that during construction, the wet concrete is not hardened yet so there is no strength in it. In this case, the weight of concrete will count as a live load rather than a dead load. Live loads are the major cause of deflection in the beam, once deflection exceeds a limit, the beam will buckle and fail. The deflection of the beams during construction governs the size in most unshored construction cases. In the case of skyscrapers, it is crucial to limit floor depth to maximize the usage of height. However, since this project is much smaller in scale, there is no concern with maximizing height usage as we are limiting costs. Since the objective is to save the owner money, the proposed structure was designed as unshored. The flowchart in Figure 30 shows the method used for roughly sizing the full-composite beams used in this project; further design verification is required.

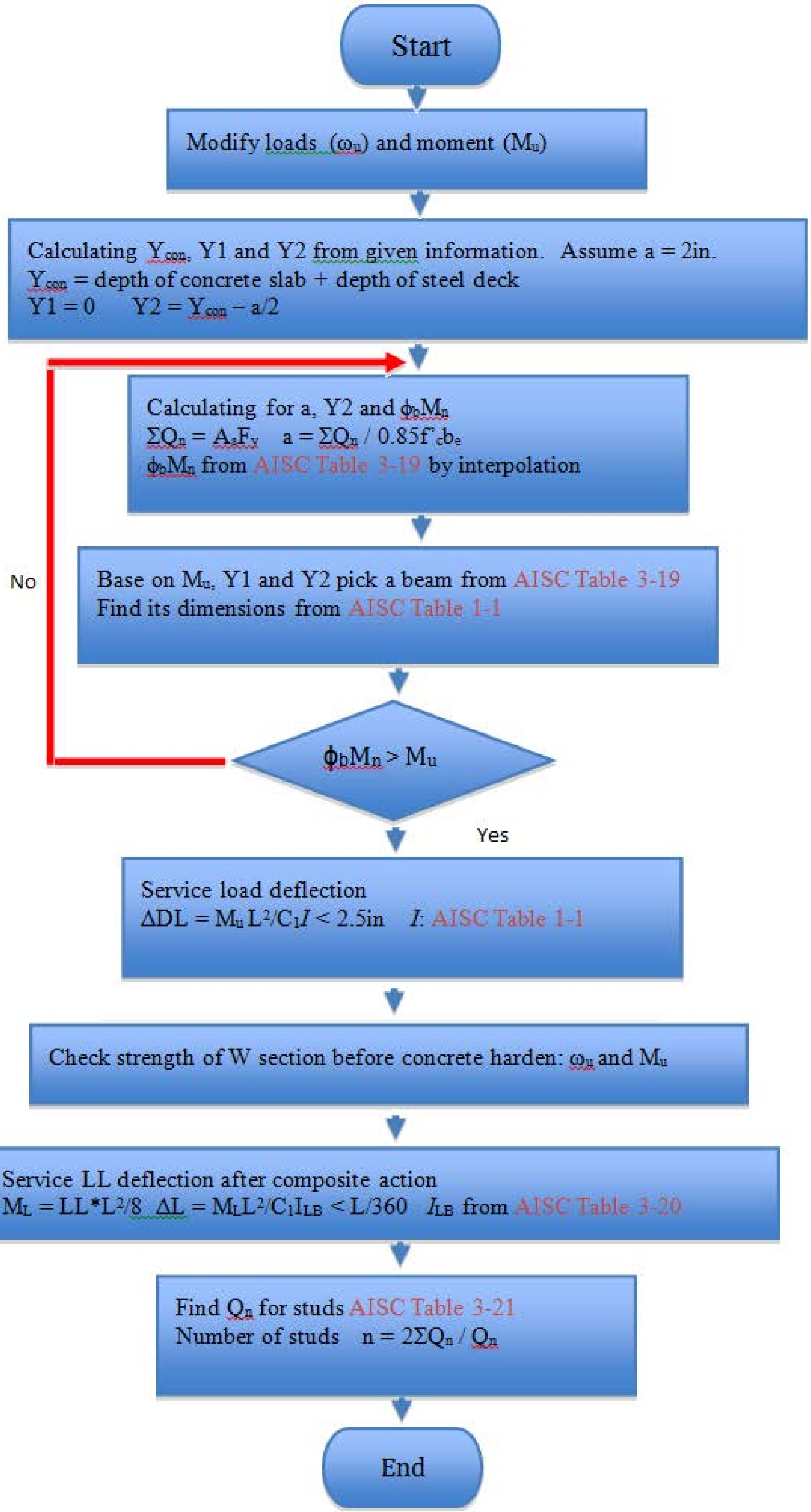

Figure 30: Beam Design Flow Chart

The results and corresponding calculations used to determine the beam sizes can be found in the Appendix B of this report.

Secondary to finding the beam sizes for this building is defining the girders, which support the beams. Although there are only two different size structural bays in the proposed building, there are actually four applications for different size girders. The first of which is at the end of the 39 foot bay, the second is between the 39 foot bay and 36 foot bay, the third is between the two 36 foot bays, and the fourth one is at the end of the 36 foot bay. The concept used for designing the girders is essentially the same as the one used to design the beams. Typically instead of using uniform distributed loads, point loads are used at the points where beams connect to the girder. However, in the design the team is using, the beams will be spaced at 5 feet on center and there will be four point loads on every girder. Therefore, the loads are evenly distributed along the girders to provide distributed loads of ωLL and ωDL. The sum of the factored ωLL and ωDL are used to define the maximum moment applied to the girders and check whether or not the selected W shape beam is sufficient for the loading case. ωLL is also used to calculate the deflection of the girders, by using equation $\Delta = \frac{5\omega L^4}{384EI}$. The other difference is that there is no need to check the strength and deflection for girders during construction. These calculations can also be found in Appendix B of this report.

The next step in the structural design is to determine the size of the columns. To do so the beam and girder weights must be added to the dead load of each floor. This new dead load, in combination with the live loads, was used to calculate the columns. There are twenty columns in this structure, in order to simplify the design concept, material ordering, and structural assembly process, our team divided these twenty columns into three groups; corner columns, edge columns, and interior columns. When calculating these twenty columns, the team designed for the ones that have the biggest tributary areas in each case. For corner columns, the ones with the largest tributary area are located at the corners of the 39 foot structural bays. For the edge columns, the biggest are between the two 39 foot structural beams. For the inside columns, the governing columns are at the intersections of the two 39 foot bays and the 36 foot bay. In the design W shaped beams are used for inside columns, and Rectangular HSS beams are used for corner and edge columns. As the columns are compression members, the compression force that is applied on each column needs to be defined. The first step in sizing the columns is to list down all the dead loads, which include weights of concrete on deck, beam weight, MEP, ceiling and partitions. The same is true with the live load which is 40 psf for residential/office space according to the ASCE Regulations and 50 psf for the snow load on the roof. The next step is to determine each column's tributary area which is determined based on the fact that each column supports a quarter of the load of each structural bay in which it connects to, and the four quarters are added together. By multiplying the load combination with the respective tributary area, the point load P_u on the column is determined.

In order to size the column, one must first assume a $\frac{kL}{r}$ value, and then go the AISC Manual 4-22 to find the corresponding $\Phi_c F_{cr}$ value for Grade 50 steel. The area of the column is represented as $\frac{P_u}{\Phi_c F_{cr}}$. By going to the AISC Table 1-1 for W Shape and Table 1-11 for Rectangular HSS shape, one will find the right shape beam according to the calculated area. In the Tables one will find the radius of gyration of the X Axis and Y Axis, and the smaller of the two will govern the $\frac{kL}{r}$ value. After this is determined, one must turn back to AISC table 4-22, to find the corresponding $\Phi_c F_{cr}$, and find the required area by using $\frac{P_u}{\Phi_c F_{cr}}$. These steps must be repeated until the area of the column is larger than the minimum required area. Finally, one must turn to table 4-1 for W Shape beams and Table 4-3 for Rectangular HSS shape beams, and check the chosen columns' $\Phi_c P_n$ and make sure that it is larger than the point load P_u that is applied on it. To simplify the explanation of these steps, the calculations can be seen in Appendix B of this report.

With all of the steel properly sized, the final large task was to calculate the necessary size footings. In this structural design, reinforce concrete spread footings were used for the columns. The size of a footing is primarily governed by two criteria, one is the load in which the column applies to the footing, and the other is the soil bearing capacity. The soil bearing capacity has to be determined by a series of tests and therefore it is assumed for this site. The site that Friendly House is located on is formed by significant amount shale which has a capacity of 40ksf. However, the actual value for this site quite possibly may be smaller since the site is likely to be a combination of soil and shale, which would in turn lower the soil capacity.

The load which the building applies to each footing depends on the tributary area of the corresponding column that the footing supports. Most columns in this new facility support both residential floors and the green roof. The same procedure that was used in column design is applied here, and all the loads with the column's tributary area are converted to a point load. Dead load in this case will be the weight of structure and green roof, while the live load will be the service load on each floor and roof, beside dead and live loads, snow load also need to be taken into consideration. The formula used for calculating the total loads applied on the footings is seen below.

$$L = 1.2D + 1.6L + 0.5S$$

Once both the soil capacity and loading were defined, the minimum required size of the footing was calculated by dividing the factored load by the soil capacity. The dimension of the square footing is simply taking the square root of the area.

$$A = \frac{Load}{Soil\ capacity}$$

$$width = \sqrt{A}$$

Sizing calculations resulted in three different size footings depending on which column they were to support. The three resulting sizes are 18”x18”, 26”x26”, and 36”x36”. In order to simplify the cost estimating and construction process, the group decided to use 36” x 36” for the size of all the footings. This was decided for two reasons; one is to simplify drawings and cost estimates, and two, because the soil capacity is likely less than the 40ksf that was assumed.

Further research should verify this soil capacity value by consultation with local professional, and the footing size and necessary reinforcement should be recalculated and verified according to the previous procedure. Figure 31 shows a cross section of the concrete footing used in the design and Appendix C contains additional cross section details. It should also be noted that the foundation pier has been over designed in order to accommodate the 8 inch exterior wall.

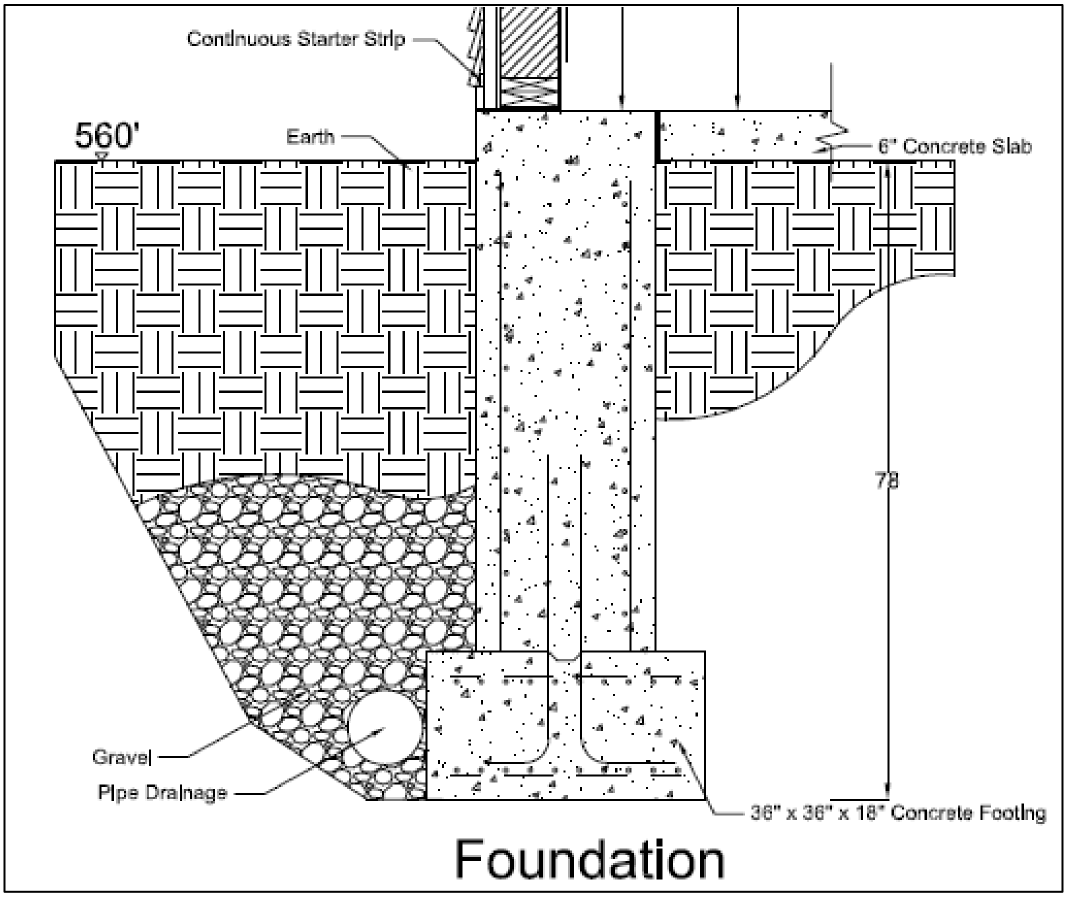

Figure 31: Concrete Footing Cross Section

The final component that the team looked into was the design and placement of shear walls to prevent any failure due to side-sway. According to international building codes, structures located in the Massachusetts area need to consider wind and seismic loads as design factors. Buildings act as a cantilever beam, in which only one end is fixed, and will start swaying as loads are presented. As the building height increases, more displacement will occur towards the top of the structure. Those displacements will result in a failure of the structure. Therefore, structural members that are used to stop the building from side-swaying must be installed and sized. Since the direction of wind and earthquake loads cannot be predicted, both the East-West and North-South directions are required to be braced against the sway.

In this project, the team decided to use both shear walls and V-Shaped bracing. The placements of the shear walls and bracings were critical because they had to be continuous throughout the entire building from bottom to top. The major constraint was that the layouts of the commercial kitchen and café area on the first floor could not be affected by the bracing locations. Thus, in the North-South direction, shear walls were installed on both sides of the stairs so that the exterior glass walls would not be altered. These shear walls were designed with concrete masonry units due to their high strength and relatively low cost. In the East-West direction, V-Shaped bracing was chosen and placed inside the exterior walls on the North and South side. The V-Shaped bracing worked best for this section of the building because it can be installed in a way where it doesn't affect the windows of the apartment complex. Figure 32 shows the placement of the bracing and Appendix C contains additional drawings illustrating their configuration throughout the building. Due to a limited time frame, the size of the shear walls and bracings were not designed in this project. Future projects should look into the proper sizing and placement of the steel members and concrete masonry units.

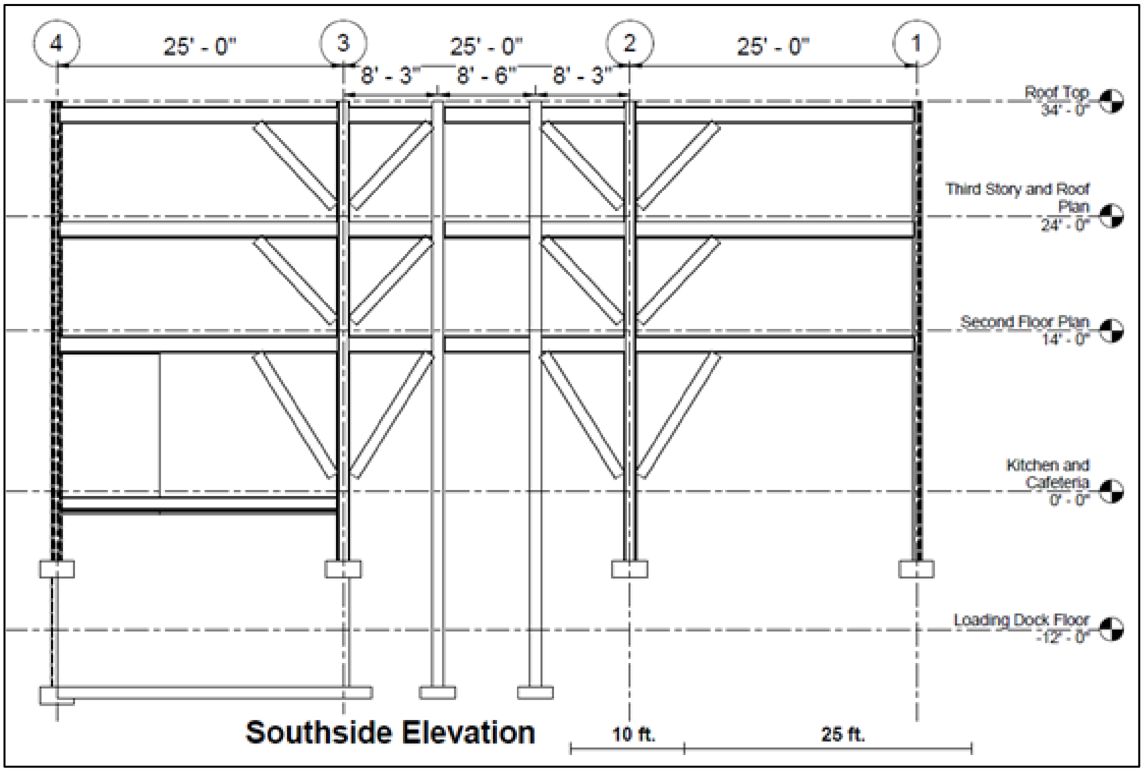

Figure 32: Shear Wall Bracing

Architectural Design

After the structural framing of the building was determined, along with complying with all applicable codes, focus shifted back to completing the floor layouts. In doing so the team had to tackle the integration of stairwells and exit points. The issue discovered was that the people who will be living in the apartments are not the same people that will be eating in the cafeteria; therefore requiring separate entrance points. Due to the fact that the apartments are above ground level, and they cannot enter through the café, there must be a set of stairs outdoors that lead onto the third floor and then continue indoors up to the fourth floor. The difficult part was determining the most practical way to do so, while maintaining a clear and concise flow for both residents and visitors alike. It was decided that a set of exterior stairs must be placed parallel to the building, leading directly onto the first floor of apartments. Once the stairs reach the apartment level, a simple wrapping stairwell aligned with the corridor will suffice in getting residents up and down from the two levels. To better illustrate this configuration, an illustration can be seen below in Figure 33, while additional drawings can be found in Appendix C.

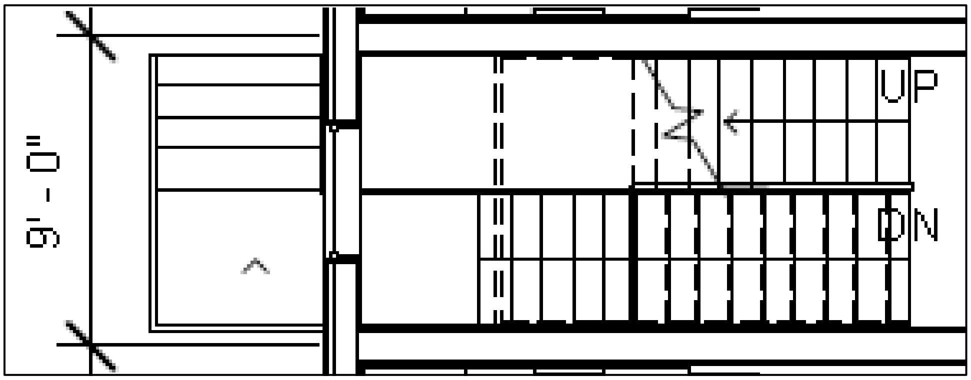

Figure 33: Stairwell Configuration

This configuration will be replicated on both ends of the building, not only to simplify access, but also to comply with egress building codes. Building codes require a point of exit from any location of the building in case of fire or another emergency. Providing direct exit access at both ends of the corridor, this requirement is met. Another regulation that must be met in regards to egress is the width of the corridor in which residents must use to exit the building. Building codes require a minimum width of 8 feet in the corridor and 5 feet in the stairwells. Therefore, the width of the corridor and stairwells are sized as so.

Besides access to the apartments, the team also had to assure easy access to and from the cafeteria and kitchen. To do so, doors were laid out on both ends of the building, with one in the kitchen and another in the cafeteria. These would again provide a way of exiting the building from any location within in the case of an emergency. These doors were designed to be located beside the outdoor stairs to facilitate common points of access. Based off of the location of these doors, the kitchen and cafeteria could be laid out accordingly. When designing this floor, our team had several considerations to keep in mind. The first of which was laying out the kitchen in an orderly fashion that allows for smooth transition from the storage area to preparation tables, to cooking equipment, and then to a serving counter. Amongst this fluid design, our team had to work around an elevator shaft that will be used to transport food to and from the kitchen to the loading dock. It was important to allow enough room for all of the necessary kitchen equipment requested in our preliminary interviews, while maintaining enough room for movement of goods and personnel necessary to prepare large quantities of food. In addition, an employee restroom had to be accommodated within our layout. With the desire to systematically layout the kitchen in a logical fashion, our team designed the following layout that can be seen in Figure 34.

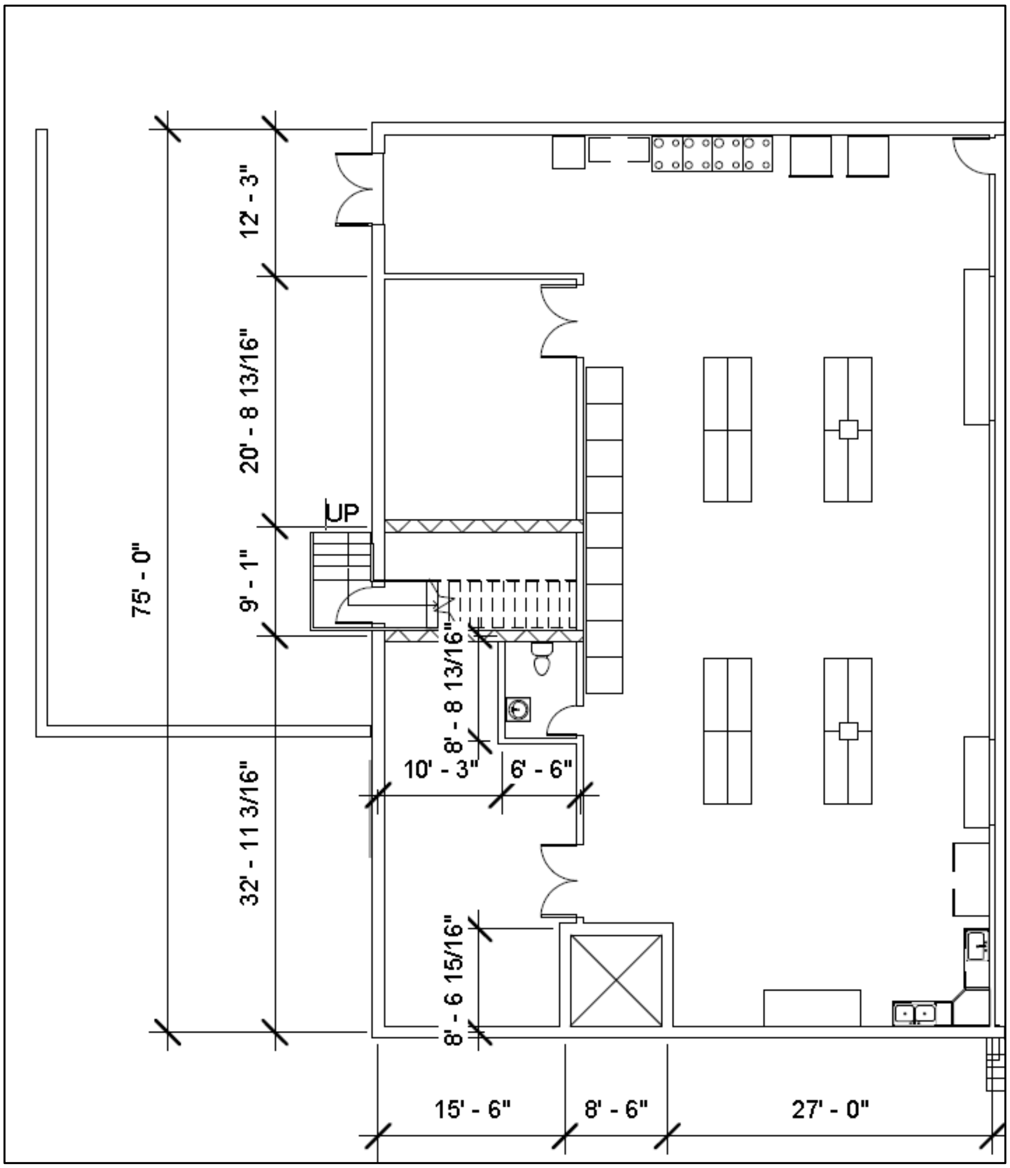

Figure 34: Kitchen Floor Layout

With the kitchen layout complete and the location of serving counters determined, the team moved on to designing the cafeteria. This space needs to accommodate as many people as possible while maintaining a spacious and comfortable feeling. To do this, the team incorporated a combination of long, cafeteria style tables with round, café style tables. The traditional long tables are used to pack a large quantity of people in, while the modern round tables add a sense of class, relaxation and spaciousness. In addition, there must be public bathrooms for both males and females. It was determined that for the amount of space and number of people that will be accommodated, there must be three bathroom stalls for women and four for men (Balboni, 2011). These bathrooms need to be located in an area which is easily accessible, yet does not hinder the flow and design of this space. For this reason, the bathrooms were located adjacent to the stairwell in the cafeteria. While still attempting to maintain logical flow of persons through this space, the following Figure 35 illustrates the floor plan our team decided upon. Additional floor plan drawings can be found in Appendix C.

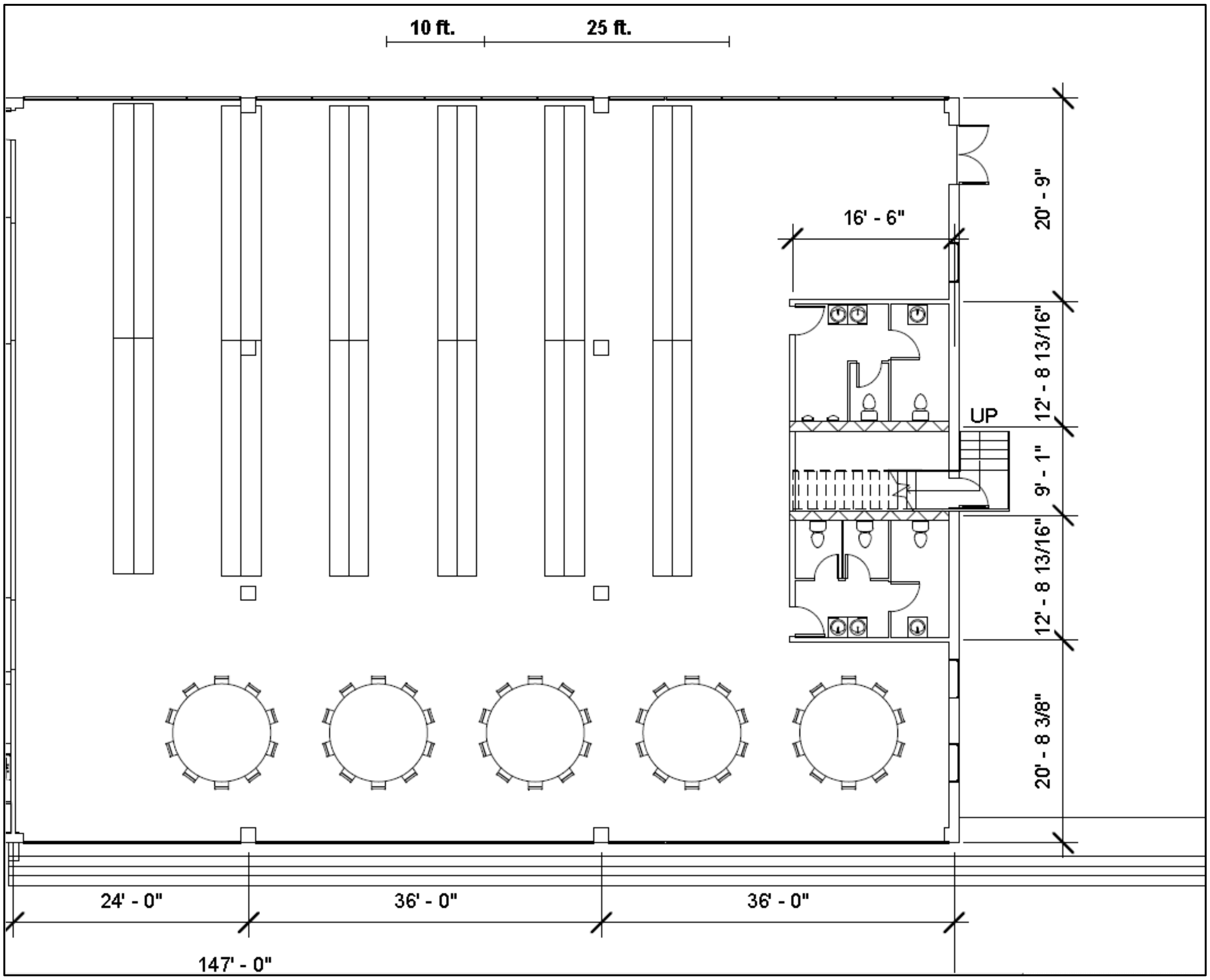

Figure 35: Cafeteria Floor Layout

Exterior Facade

A brief exercise of architectural design of the façade was needed. Keeping to the notion of wanting to create a "green building", Professor Pietroforte suggested we look into energy efficient panels to be used on the outside of our building. These panels would offer a simple means of exterior coverage, while increasing the R-value of the walls. After researching several types of panels, it was realized that these panels were becoming very popular due to their ease of construction and increased level of insulation in the building. The team chose to use sandwich panels that will easily hang on the outside of the structure and give the building a clean look, while lowering the cost of construction. The other advantage is their increased energy efficiency. The state of Massachusetts requires a minimum R-value of 13 in the walls (*Residential Energy Efficiency*, 2009). This R-value dictates how much heat energy is transferred in and out of the structure. In addition to the wall, there are also requirements for minimum R-values in other parts of the building. Table 4 displays the minimum R-value requirements for the state of Massachusetts.

Table 4: Minimum R-value Requirements

Object	R-Value
Ceiling/Roof	38
Mass Wall	13
Wood Frame Wall	20
Floor	30
Slab	10

The sandwich panels proposed for this building come in 4 inch and 8 inch thicknesses, which have respective R-values of 13 and 25. Therefore, the team designed the building to use the 8 inch thick panels resulting in a wall R-value of 25 which is nearly double the state minimum. The idea of increasing the building's R-value this much is wonderful in the eyes of the Friendly House. These panels would help move this building in the "green" direction and save money on heating and cooling costs. These panels would also assist in obtaining state funding by making an energy efficient building to help save the environment. A cross section of these sandwich panels and their integration in the design of the building can be seen in Figure 36.

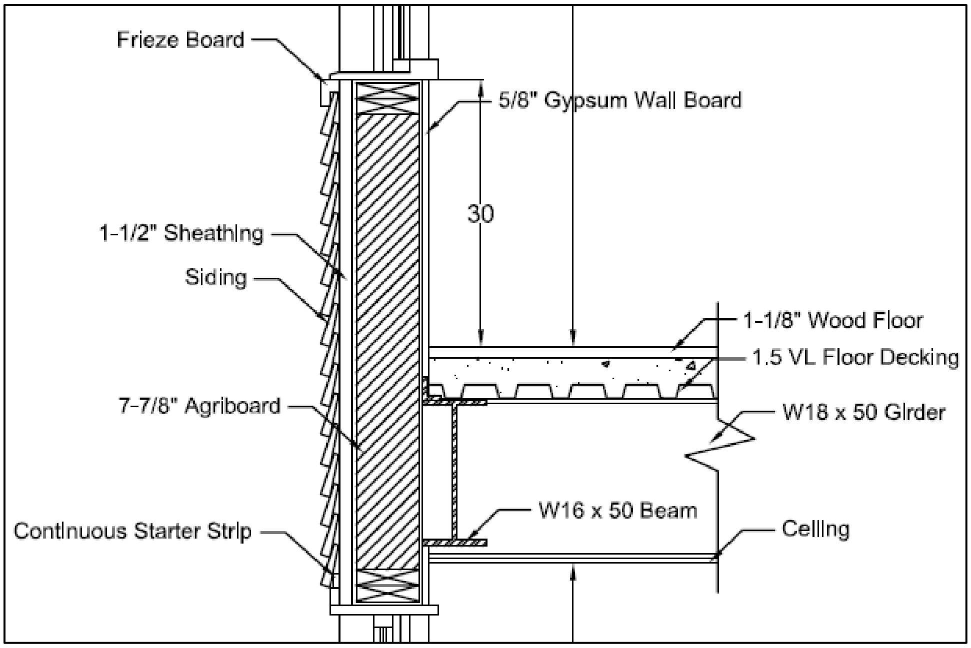

Figure 36: Sandwich Panel Cross Section

However, with such a large building, it was a concern that if panels were used on the entire structure, it would appear too “plain”. To remedy this, the team looked into choosing a different facade for the small loading area on the street level. The team wanted to create a separation from the rest of the building while maintaining a traditional Worcester look. To do so we chose to use stone masonry for this area. It is relatively small so it should not drive the price up that much and it will also blend in nicely to the retaining wall that will be running alongside the loading dock the length of the site. This loading dock façade and retaining wall can be seen in Figure 37 below.

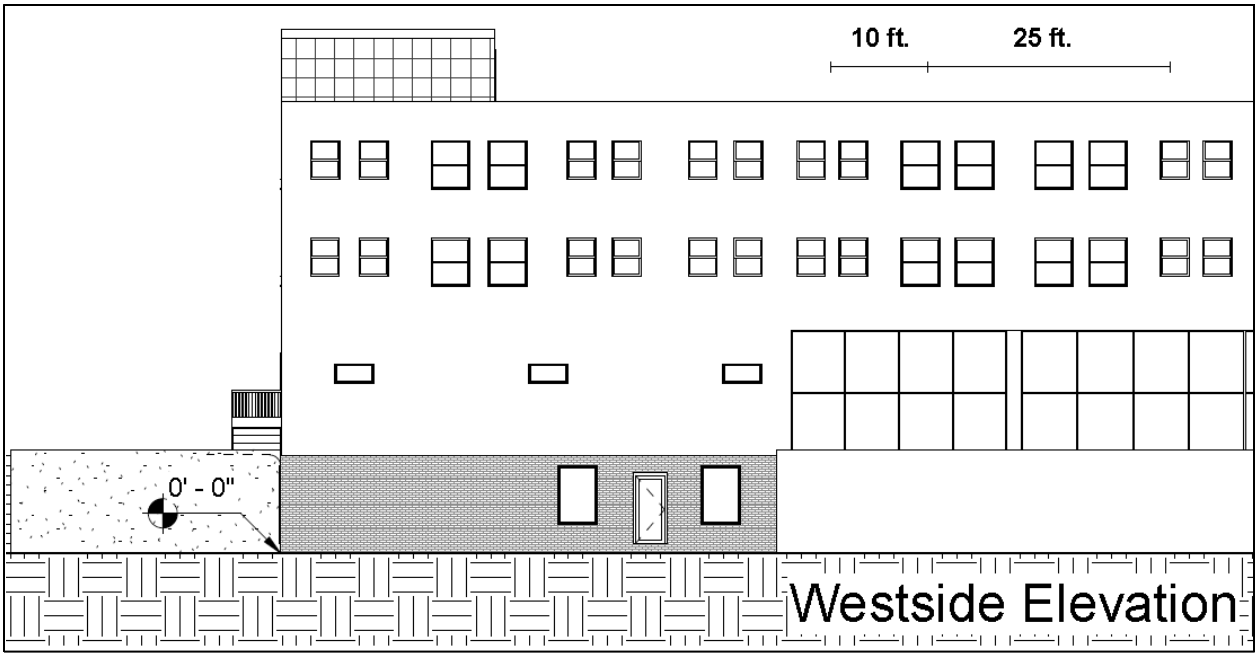

Figure 37: West Side Elevation (Loading Dock)

In addition, we wanted to open up the cafeteria area to allow natural sunlight in and give this space a cozier feel. To do so, it was decided to make the east and west walls of the cafeteria glass curtain walls using low-emissivity, double-pane glass. Although this will increase the price of the building, it will add value to the building by making it a more welcoming place for community members to come together. However, it must be assured that the costs do not outweigh the benefits. In addition, it must be confirmed that these glass walls meet the minimum U-factor (.35) for glazed fenestration in the state of Massachusetts. This U-factor dictates how much heat energy transmits through the glass and how much reflects off of the surface. Further research into the nature of these glass curtain walls is necessary to determine whether their use is appropriate. An architectural elevation of this space can be seen in Figure 38 while additional elevations views can be found in Appendix C.

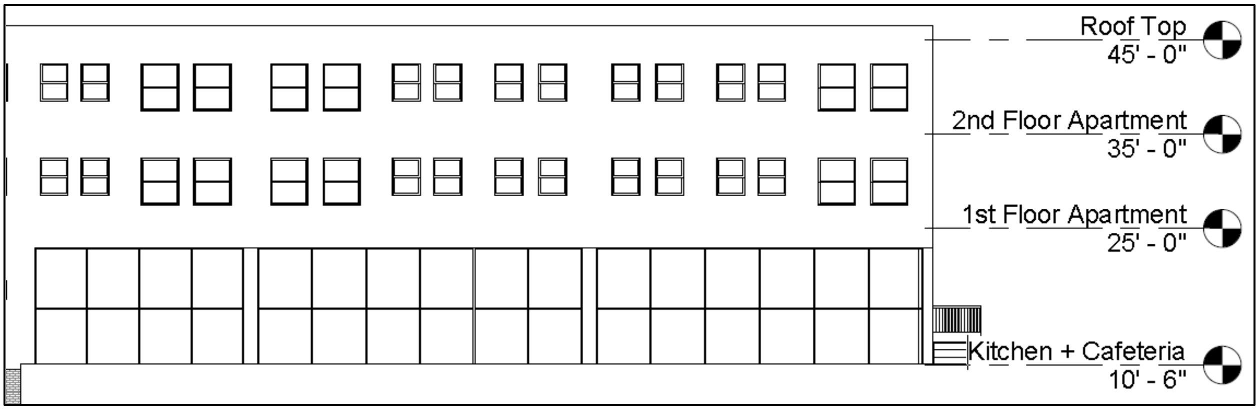

Figure 38: West Side Elevation (Glass Facade)

Alternatively, the glass surface area could be reduced to maximize the R-value of this space while still allowing some natural sunlight to enter. This option may be more economical for the Friendly House is they feel that this space will not benefit greatly from the incorporation of glass curtain walls. This alternative design can be seen in Figure 39.

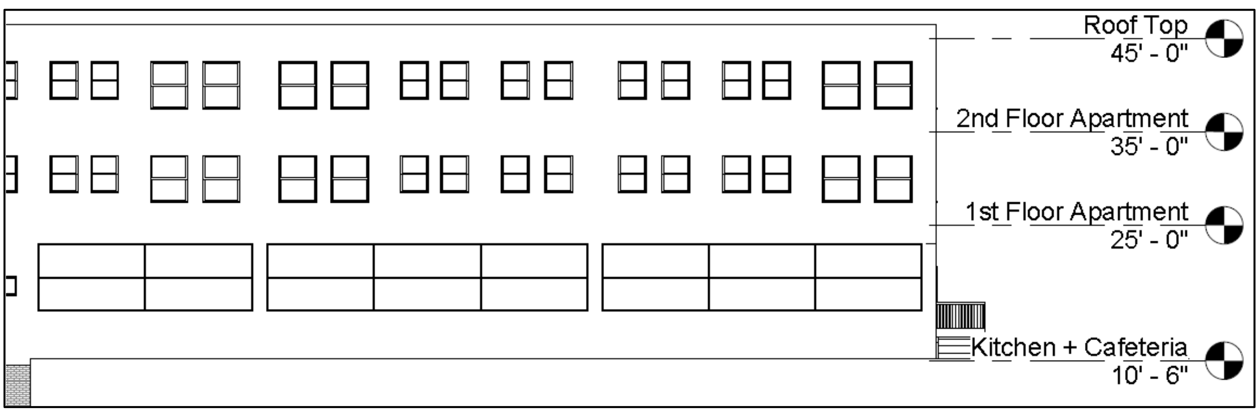

Figure 39: Alternative Glass Facade

Lastly, as previously mentioned, the team decided to design a roof garden on top of the building to stick with the concept of a "green" building. As previously shown in Table 4, there are R-value requirements for the roof of a building. The Massachusetts minimum R-value for a roof is 38. To achieve this R-value, insulation is used. For each inch of insulation, an R-value of 5 is achieved (*R-Value Table*, 2011). Therefore if four inches of extruded polystyrene insulation is used, an R-value of 20 is achieved. To reach an R-value of 38, additional insulation of some sort is needed. A roof garden will do just this by providing a large amount of insulation. For a typical roof garden, each inch of growing media results in an R-value of 5, therefore with the designed 3 inches of growing media, an R-value of 15 is achieved (*Method for Determining the Resistance*, 2000). The combination of growing media and polystyrene insulation gives an R-value of 35. The concrete on deck, waterproofing, and layers of soil filtration will allow enough insulation to supersede the Massachusetts minimum requirement of 38. This is extremely important as the largest amount of heat in a building is lost through the roof. Designing a roof garden for this building will help minimize heat transfer greatly and further improve the building's energy efficiency. This roof garden not only helps make the building green, but it also serves as a way to help counterbalance the increase in storm water runoff created by the additional impervious surfaces. When permitting any project of this size, there are several regulations that must be met to assure low impact development. Two of the main stipulations when submitting a storm water pollution prevention plan (SWPPP) are one, that with the development there is not an increase in impervious surface area, and two, that the pollution coefficient does not exceed the set number for the district area. Although the rain garden alone may not satisfy these requirements, it will certainly make the project a lot more doable. However, to assure the efficiency of such a roof garden, further research is necessary to determine the best practices for waterproofing and drainage. An illustration of this roof garden can be seen in Figure 40.

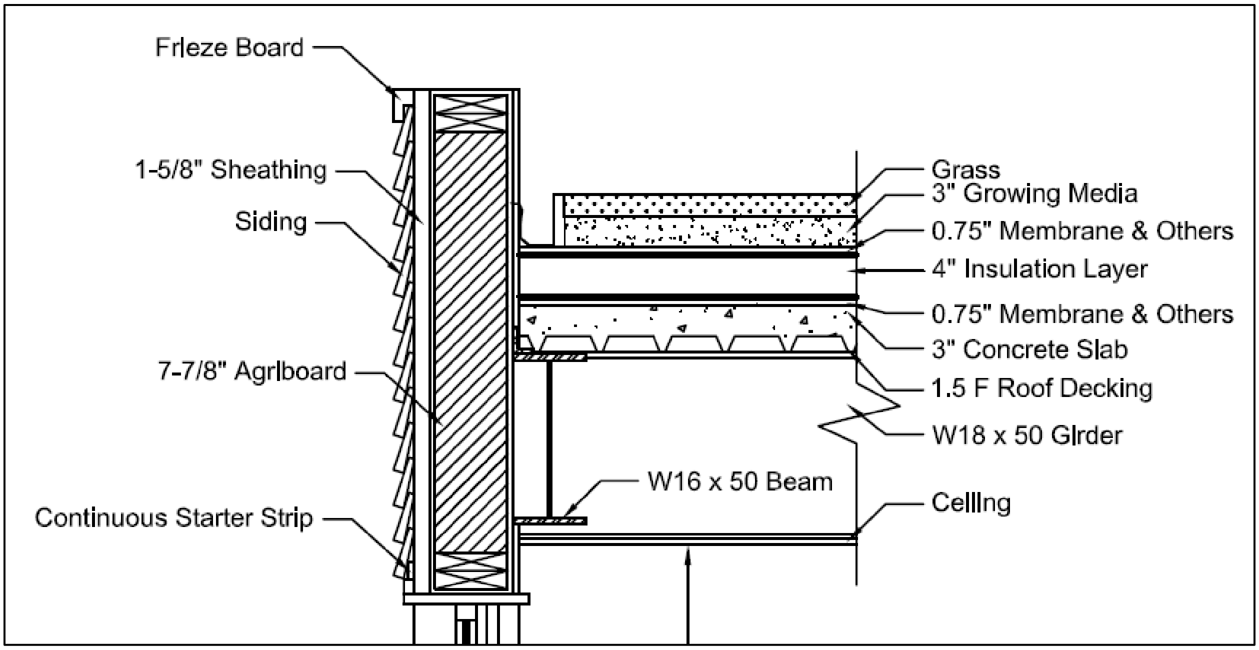

Figure 40: Rain Garden Cross Section

Chapter 4: Schedule & Cost

After all design phases were completed, the project team developed a schedule and cost estimate for the construction of the housing complex. A schedule is useful to the Friendly House so that they can gain an understanding of the duration of construction for such a building. The cost estimate provides a preliminary expense figure to the Friendly House that can be used to determine the economic feasibility of constructing the building. Both the schedule and the cost estimate were developed with the intent of providing a general overview of the project duration and cost respectively, but further analysis should be done to produce more precise results.

Schedule

In order to predict the approximate time required to fully construct said transitional housing complex, a schedule was made using a program called Microsoft Project. This program is used to map out the construction process in logical order and outline the time required in each step of the way. With the restraint of time, our project team decided that a detail schedule was out of our reach. Instead it was chosen to list down a serious of main activities that would be critical during the construction to get a good idea of the time frame. All the activities and their durations were defined with respect to a previous MQP project that was done on a similar structure of similar size. Most of the activities' durations are only rough assumptions based on previous projects and therefore should not be looked upon as exact.

Due to the current condition of the site, excavation and retaining walls will take the longest period of time. Friendly House is located on a site composed mostly of shale and has an elevation difference of as much as 30 feet at some locations. Per the previously discussed master plan for the new Friendly House facility, there are two main retaining walls that must be constructed. The first of which is located in front of the new facility and stands 10 feet tall, and the other is located behind the residential complex and will stand 20 feet tall. In order to flatten the surface between these two walls, a large amount of excavation and fill will be necessary. The combination of the large retaining walls and the mass excavation will take a significant amount of time depending on the soil conditions. Therefore, the team decided to allow 120 days for construction of both the 20 foot and 10 foot retaining walls to be performed simultaneously.

For some of the activities, such as erecting steel and installing floor decking, durations were calculated based upon a similar MQP project. Since the structure in that project is approximately the same size, time consumption for those activities would be proportional. The area used in the previous project is about 1.62 times larger than the area of this project; therefore the duration for some of the activities on this project should take 1.62 times less amount of time to complete. Meanwhile the durations of some of the other activities stayed the same as the previous project, such as placing concrete slab on each floor and roof. The reason behind this is that it takes a certain amount of time for concrete hardening to reach a critical strength regardless of slab size; therefore the durations of such activities stayed the same as the ones from the previous project.

After all of the activities were listed in chronological order and their durations were computed, the group organized them and listed down the successors of each activity. Microsoft Project created a whole schedule based on the group's input, and found a critical path of this schedule. According to the schedule, the entire construction process should take place from March 3rd 2014 to October 23rd 2015, with a duration of 19 months and 20 days. A detailed task breakdown, along with the mentioned bar chart can be found in Appendix D. Again, this is a rough estimate with several assumptions so further research should be done to verify the accuracy of this estimate.

Cost Estimate

The design and schedule of this project is useless unless there is a cost associated with it. The team needed to provide a rough estimate of the cost of constructing such a building in order for the Friendly House Board of Directors to determine if this project is even feasible. In an attempt to do so, while battling the restraint of time, our team looked to R.S.Means for assistance. R.S.Means is a cost estimating reference book that has up-to-date cost information for all aspects of a construction project. This reference book outlines individual products and tasks with individually allocated cost/unit or cost/square foot for each. These prices include material, labor, and shipping, making the estimating of a large building much simpler. It also includes location factors that adjust the price depending on where in the country the project is to take place, broken down by city and state. Lastly, it also provides inflation data for the past ten years again broken down by city and state. This allows for a very accurate cost estimate with a bit more ease. The team went through the 2011 R.S.Means Square Foot Costs reference manual page by page and recorded the cost for every element of the proposed building. Table 5 shows a breakdown of the costs for this building. A detailed breakdown of this cost estimate can be found in Appendix D.

Table 5: Summarized Cost Estimate

Category	Details	Total
Structure	Columns and Structural Framing	824458
Substructure	Footing, Slabs, Foundation Walls	121647
Shell	Floor Construction, Exterior Window and Doors	1068651
Interior Construction	Drywall, Floor Finish, Paint, Partitions	813649
Conveying	Elevator	62900
Plumbing	Water Closet System, Bath/Kitchen Sinks	312848
Heating and Cooling	Apartment A/C and Heating	467150
Fire Protection	Sprinkler System, Pipe Risers	142462
Electrical	Lighting and Branch Wiring, Communications	386500
Equipment & Furnishings	Washers, Dryers, Food Service Equipment	206356
Building Sitework	Earthwork, Roadways, Sewer	N/A
	TOTAL	4406620
	Expected Cost in March 2014 w/ Assumed 2% Inflation	4607401
	Expected Cost w/ Location Factor of 1.10	5068141
	Overhead and Profit (25% of Total Cost)	1267035
	GRAND TOTAL	**6335176**

As you can see in the above table, the costs are divided by category and within each category they are broke down further by details. This summary table leaves out the individual detail prices and sums up the totals of the categories. The majority of the prices are directly taken from the 2011 R.S.Means square foot costs manual. The team went page by page through said book and recorded the price and quantity for everything that is included in the designed building.

A few items were not found in the R.S.Means book and therefore were assumed. One of these assumptions was with the Agriboard panels. Since these panels are relatively new and not often used, their square foot cost is not found in this manual. Therefore research was necessary to determine the cost. The Agriboard website advertised a material cost of $2.37/square foot. However, the team still had to determine an approximate cost for transportation and installation. A study was done in New Hampshire in 2011 to determine the cost of installation of the Agriboard panels. It was determined that installation cost $0.97/square foot; however, this price had to be adjusted for labor rates in Massachusetts. After adjusting these rates it was determined that an installation cost of $1.08/square foot could be expected in Worcester. The last element was to estimate the shipping cost. Agriboard is manufactured in Texas resulting in long distance delivery so our team made an educated guess for transportation costs of $1.00/square foot.

It must also be noted that a few aspects were not included in this preliminary estimate. One item that was left out is the furniture and the other is excavation. Furniture was left out because specific furniture items are not included in the R.S.Means manual and would result in a very tedious task of having to choose which furniture the Friendly House would like to have. Therefore we left these items out to be determined by Friendly House staff. The excavation was left out due to the number of assumptions and variables involved in pricing. As stated before, the Friendly House site has a lot of shale and the actual soil conditions throughout the site are unknown. Depending on how much shale is present, the cost of excavation could vary greatly. In addition, with the apartment complex being located on Montreal Street, the existing structures will need to be knocked down and cleared out. With so many unknown variables, the project team did not perform a complete cost estimate of the site work because of the inaccuracies that would be inevitable. However, the project group felt it necessary to discuss the implications that the subsoil conditions would have on the cost of site work. Pictured below in Table 6 are the excavation costs for solely the footprint of the building with a 10 foot additional offset on all sides except the West End.

Table 6: Excavation Cost Estimate

Excavation Conditions	Quantity of Common Earth (B.C.Y.)	Quantity of Rock (B.C.Y.)	Total Cost
80% Common Earth, 20% Rock	3130.4	782.6	18782.4
70% Common Earth, 30% Rock	2739.1	1173.9	23869.3
60% Common Earth, 40% Rock	2347.8	1565.2	28956.2
50% Common Earth, 50% Rock	1956.5	1956.5	34043.1
40% Common Earth, 60% Rock	1565.2	2347.8	39130
30% Common Earth, 70% Rock	1173.9	2739.1	44216.9
20% Common Earth, 80% Rock	782.6	3130.4	49303.8
Total Excavation Required= 3913 C.Y.			
Common Earth Excavation = 2.20/B.C.Y.			
Drilling Rock, Open Face = 15.20/B.C.Y			

The table illustrates the effects that rock within the subsoil has on the total cost of excavation of the 3913 C.Y. of cut that is required for the area. It is seen that as the percentage of rock rises, so does the total cost. With only 20% rock it would cost approximately 20,000 dollars. Meanwhile, if the subsoil consists of 80% rock, that figure rises close to 50,000 dollars. This is caused by the extreme increase in costs per C.Y. for excavation of subsoil with rock compared to common earth. According to R.S. Means (2011), drilling rock is almost 7 times more expensive to excavate than common earth.

The project team realizes that the cost estimate shown above is much less than what the actual figure would be because it has excluded costs associated with other components like temporary retaining walls, the relocation of utilities, and demolition. However, it can still be observed how much of an impact the subsoil conditions can have on the total cost. It is know that there are large amounts of shale in the area, but its' precise quantity is not known. Thus it would be extremely useful to gather this information in order to perform a more accurate estimate of the site work. In fact, if there is an enormous amount of shale present, Friendly House might find it too costly to excavate this particular area, and may deem this project impractical.

In addition to the basic costs of this structure, the team also had to adjust the final cost for location, inflation, overhead, and profit. The price of this project needs to be factored with inflation as the project will not take place this year. For this project's sake, it was assumed that construction would not take place until March of 2014 and would last till September of 2015. Therefore, inflation must be considered for the next two years. R.S.Means includes inflation factors for the past ten years that were used to determine an expected inflation of 2% for the next two years. By adding 2% inflation to the total cost of $4,406,620, an estimated cost for the year 2014 was determined to be $4,607,401. If the project is stated after the assumed March 2014 date then additional inflation must be considered. Also, the prices found in R.S.Means are a national average that needs to be factored to determine the expected cost in Worcester Massachusetts. Worcester has a location factor of 1.10 meaning that the total price of $4,607,620 must be multiplied by 1.10 resulting in a cost greater than the national average of $5,068,141. Finally, profit and overhead must be added to accurately determine the expected cost for this project. R.S.Means uses a default value of 25% to cover the contractor's general expenses, overhead, and profit margin. After adding this 25% a total cost of $6,335,176 is expected. Again, this cost does not include everything needed for this project but it offers the Friendly House an accurate figure that can be used to determine if this project is feasible as is or if it needs to be evaluated further.

Chapter 5: Results & Conclusions

Since this project first began, it has evolved and improved in several ways so that the final product could help the Friendly House organization as much as possible in achieving their goals. From developing a proper scope, to creating a master plan, and finally designing a low-income transitional housing complex, there have been several steps taken in each phase to complete the project in such a way that the team feels like the Friendly House can truly benefit from it. Upon completion of the project, the team conducted a presentation to the Friendly House board of advisors that generally explained the above-mentioned steps and final results. This section of the report provides a more detailed overview of what was presented to the Friendly House and discusses what the project team has been able to accomplish. It also addresses several issues that need to be considered in the future so that Friendly House can one day realize its ultimate goal.

Master Plan

Over the course of the project, two different master plans were developed that revolved around two scenarios: one which included a new gym facility and one which kept the existing gym facility in-tact. After collaboration, the team concluded that the master plan with the existing gym would be most practical and economically feasible. Thus, this master plan was used as the final product presented to Friendly House. The plan keeps the "tiered" concept in mind that was discussed in the beginning phases of the project and allows for a separation of recreational activities. The second, upper tier consists mainly of the recreational playing field and the area of land that will be utilized by the city of Worcester as a park. Meanwhile, the first tier is where the main buildings are situated along with the parking lots and additional recreational areas. As the master plan indicates, the final size of the new Friendly House facility was determined to be three stories and approximately 39,375 square feet and will connect to the existing gym. The low-income, transitional housing complex is located farther North and was designed to be three stories as well with a loading dock for a total of 35,096 square feet. Comprising the rest of the site, the parking lots along with roadside parking will satisfy Mr. Hargrove's requests of parking space. All of these elements, integrated with the green space, walkways and stairways formulate a master plan that will surely meet the needs of the Friendly House and the community residents whom utilize their services.

With all this being said, the most convenient and pleasing master plan is not always the most feasible. The team indeed believes that the Friendly House site can one-day achieve the designed master plan, but also suggests that certain elements should be further considered to check for feasibility. The major variable that this master plan depends on is whether or not it will be economically possible to alter the site so all of these components can take place. First off, previous sections show how much more expensive it is to excavate shale compared to common earth, so before this master plan can become a reality it must be checked that the cost of excavating the large amounts of shale throughout the site and leveling the land where need be is worth it to the Friendly House. If it is in-fact economically feasible for the site to be excavated properly, retention walls will then need to be constructed throughout the site. The quantity of retention walls that are needed in order to make sure that the site remains stable will undoubtedly be another enormous cost. Therefore, Friendly House should examine if it really wants to remain with this "tiered" system (where large retention walls will be needed), or if it should consider an alternate design that will reduce the need for retention walls across the site. If the Friendly House can consider such potential complications and address them, then the current master plan could be altered accordingly. Either way, the team feels that the master plan is a great initial concept to build future work and studies off of in order to determine what works best for Friendly House.

Low-Income, Transitional Housing Complex

The main focus of this project was the design and implementation of a secondary structure to host an industrial kitchen and transitional housing complex. The master plan developed by the team incorporated such a building in a site design that we saw as not only practical but aesthetically pleasing as well. In a project of this size, funding was a main concern, leading to the idea of constructing low-income housing units to generate revenue. These low income housing units would serve as transitional housing for the underprivileged in the community, while supplying a steady stream of revenue for the Friendly House. Our team's research and design exercises led to a three-story building with a street level loading dock. The street level loading dock will be used to distribute meals and receive shipments to and from the kitchen, while the ground floor will be home to the new industrial kitchen and cafeteria. This space will allow the Friendly House to host large functions and provide a large quantity of food for those in need. The next two stories will host the low-income apartments, each story consisting of six two-bedroom apartments and two three-bedroom apartments. These units, and their corresponding layouts, should adequately serve the needs of the community and supply an efficient source of revenue for the Friendly House for years to come.

The structure of this building is composed of steel beams, girders, and columns, with concrete masonry units alongside the stairwells to provide shear resistance. Steel was chosen as the most cost effective structural component for this building, however, future research could be done to illustrate the cost effectiveness of steel and verify that it is the ideal material for this building. This building was designed using Agriboard sandwich panels and a green roof to save on utility costs and help create an energy efficient building. These features should not only help save money, but also stimulate additional funding from the government and private donors. Additional research should be conducted to determine if other energy conscious features could be incorporated in the current design.

The project team feels that the current design of a low-income, transitional housing complex is the best option for the Friendly House going forward. The size, location, material, and purpose were all determined for very specific reasons that made the most sense at the time. Future research should be done to verify that the current design is the best solution. Most importantly, a thorough cost analysis should be done to determine if the building as currently designed is worth the money or if it must be shrunk, expanded, or disbanded all together.

Future Projects

Due to the intensity and time constraint of this project, there are several aspects of our design that were not fully researched. These details must be taken into consideration and further evaluated in future related projects done for Friendly House. This section will outline a few areas that the team would suggest future projects concentrate on.

1) Site Evaluation: The soil condition of the Friendly House site was not defined prior to this project, so the team made a few assumptions which could be far from reality. A series of sophisticated bore tests of the soil at different locations on the site are required. The major reason behind these tests is that the structure of the house, project cost, and project duration vary greatly depending on the soil property. The footing size is fully dependent on the soil bearing capacity. Since the type of soil on the Friendly House site is a combination of earth and shale, the soil capacity changes as the percentage of each material present changes. In this case, the footing sizes will have to increase dramatically if common earth is the

dominating material, where as they can decrease in size if the site turns out to be completely shale. The cost of site work is also governed by the soil condition. If there were a lot of shale, blasting would be necessary and this would be a longer and very costly process. On the contrary, if common earth is the dominating material, extra material may be required for footings and therefore increase the cost as well. Lastly, the duration of excavation and construction of retaining walls is currently set to be 120 days for this project, and it is one of the critical activities of this construction process. This means that the changes of duration made to this activity will also change the duration of the entire construction period. If more shale was found on the site, it is most likely going to elongate the time consumption of the whole project, and push back all the activities, again increasing the overall project cost. After determining the soil condition, a future group can analyze whether or not it is worthwhile to build this new facility on this site or move it to a different location, or scrap the idea entirely.

2) Cost Effectiveness Research: Even though this project was completed under the assumption that the Friendly House had an infinite amount of money to pay for everything, the team still designed with the hopes of reducing the project cost. However, there are certainly other ways to further reduce the costs and a future group could take a closer look at where costs can be cut. At the same time, a value analysis could be done to determine how long it will take for Friendly House to get all their investment back. Based on these numbers, the group can determine if it is necessary to make any changes to the house such as increase or decrease the number of apartments or use different types of the materials for construction. It must be noted that in doing so, all of the changes that will be made to the current house

design must agree with Worcester Building Codes and all the other elements that appear on the Master Plan need to be changed accordingly.

3) Structural Design: This project was not centered on structural design, so all of the elements were roughly sized, and may need more detailed design. A future group that has a sincere interest in structural design could carry out detailed calculations to verify our results. In addition, there are several structural components that have yet to be calculated that can be a focus of a future project. Some of these components are side sway, bracing, connections, and shear studs. If soil conditions are defined and design of the upper structure is complete, the footings will need to be resized and reinforcement needs to be added. Besides the structure of the house, the two retaining walls need to be dimensioned and reinforced and/or evaluated to determine if alternative solutions exist rather than building a 20 foot tall retaining wall. In this project, the team came up with three different structural layouts, and a future group can do calculations for all three scenarios and figure out the most cost effective layout or come up with another solution. At the same time, the group could look into whether or not a steel structure is the ultimate solution for the Friendly House, or if another construction material would better suit the application.

4) Energy Efficient Design: One of the main concerns Friendly House expressed is its lack of funding for the project. An energy efficient building can be a great advertisement for fund raising, as they might be able to get more donations from government agencies and private donors to have their dream come true. In this project, sandwich panels and a green roof are the two major green features that were incorporated in design; however, there may be more energy conscious elements that can be added to further improve the energy efficiency of this complex.

5) Second and Third Phase Construction: As mentioned in the report, there will be second and third phases of this project, which include removing the current Friendly House facility, constructing a new facility in its place, and adding additional site features such as recreational space and parking. The new Friendly House facility will host all the activities that Friendly House currently provides in addition to new service they hope to provide in the near future. A future project group could look into the design, schedule, and cost estimate of the new Friendly House facility and other site components included in the designed master plan for phase two and three. At the same time, the group could also detail the exact layout of the recreational space outdoors.

Final Thoughts and Thanks

The project team would like to sincerely thank everyone who had a hand in making this project as successful as it was. It is with their help that the team could narrow its focus and produce a final product that will hopefully pay great dividends to the Friendly House organization. Working with Friendly House and everyone else involved has made this experience truly rewarding and fulfilling for the team, just as the team hopes that the completed work will be able to help the Friendly House organization reach all of its goals. With this being said, the team would like to wish everyone involved, mostly importantly the Friendly House organization, the best of luck in the future and hopes that the completion of this project has exceeded their expectation and can contribute to the bright future that Friendly House holds.

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Appendix A: Detailed Space Requirements

2011 MQP Size Requirements

Department	Square Footage Needed Per Person m² Minimum	m² Maximum	ft² Minimum	ft² Maximum	Number of People or Rooms	Required Area Minimum	Required Area Maximum	Reference Page Number
Social Service Department								
1. Staff Area								
Food Pantry	15		161.46		1	161		P 331, Neufert
Private Staff Offices (7)	12		129.17		7	904		
Executive Director Office	15		161.46		1	161		
Conference Room	1.5	2.25	16.15	24.22	8	129	194	No. 3, P128, VNR
Conference Room w. machines(assumption)	including all the equipments, which will be between 50ft²					244		
Staff Breakroom	2.25	4	24.22	43.06	6	145	258	No. 6, P128, VNR
Staff Bathroom 1970	1.4	1.68	15.07	18.08	1	15	18	P 133, Neufert
Staff Bathroom Male	roughly assumed 12ft x 12ft					144		
Staff Bathroom Female	roughly assumed 12ft x 12ft					144		
Total Staff Area						2017		
2. Social Service Area								
Classroom (2)	2	2.5	21.53	26.91	60	1292	1615	P 167, Neufert
Classroom (Assumption)	including all the equipments, which will be between 30-50 ft²					1352	1715	
Reception Room	6.7		72.12		1	72		P 199, Neufert
Waiting Area (assumption)	20ft x 20ft					400		
Clothing/Laundry Room	30		322.92		1	323		P 331, Neufert
Total Social Service Area						2510		
Total area for social service						4383		
Food Program								
Holiday Event/Food Distribution Room	20 ft² for each person and 100 ft² for staff and equip				200	4100		host in GYM
2 door fridges	11.25				6	68		
2 door freezers	11.25				2	23		
2-bay sinks	15				3	45		
reach in freezer	18				1	18		
walk in freezer	400				1	400		
stand up 4 door oven	12				2	24		
stove top oven	16.5				2	33		
Desks 4ft x 8ft	32				3	96		
storage room	900				1	900		
total equipment area						706		
total walking area						353		
Total food area						2665		
After school Department								
Staff Lounge	2.25	4	24.22	43.06	5	121	215	No. 6, P128, VNR
Conference Room	1.5	2.25	16.15	24.22	8	129	194	No. 3, P128, VNR
storage area for each room	40ft²				12	480		
Storage Room	20ft x 20ft					400		
Total Staff Area						1289		
1. After School Program								
Homework Room	1.5	2	16.15	21.53	70	1130	1507	P 162, Neufert
Homework Room (Assumption)	with additional 50ft² of eqipment space					1180	1537	
Computer Room (based on art classroom)	2	2.5	21.53	26.91	10	215	269	P 167, Neufert
Computer room (Assumption)	6ft x 8ft for each station				10	480		

Game Room	25 ft^2 for each kid				70	1750		
Muli-purpose Room	35 ft^2 for each kid				70	2450		
Cooking Room 1970	40		430.56		1	431		P 167, Neufert
Cooking Room Assumption	40 ft2 for each group				20	800		
Boys Bathroom 1970	1.56	1.72	16.79	18.51	3	50	56	P 166, Neufert
Boys Bathroom (assumption)	50ft^2				3	150		
Girls Bathroom 1970	0.96	1.12	10.33	12.06	3	31	36	P 166, Neufert
Girls Bathroom (assumption)	45ft^2				3	135		
Total youth area						7302		
2. Teen Activities								
Teen Lounge	35ft^2 for each teen				15	525		
Game Room	30 ft^2 for each kid				60	1800		
Quiet Room	1.5	2	16.15	21.53	10	161	215	P 162, Neufert
Mens Bathroom 1970	1.4	1.68	15.07	18.08	3	45	54	P 133, Neufert
Mens Bathroom (assumption)	50ft^2				3	150		
Womens Bathroom 1970	1.4	1.68	15.07	18.08	3	45	54	P 133, Neufert
Womens Bathroom (assumption)	45ft^2				3	135		
Total Teen area						2825		
3. Sports and Recreation								
Basketball Court 94x50	4750.00				1	4750		P 286, Neufert
Walking area and sitting area	100ft^2 for each court				3	300		
Storage Room	20ft x 20ft for sport's equipment					400		
Athletics Office	20		215.28		1	215		P 168, Neufert
Total indoor recreation area						5665		
4. Summer Program								
Sprinkler System Outdoors	500ft^2				1	500		
Grass playing Field (outdoor soccer field)	59400				1	59400		
Paved Court (outdoor basketball court)	364		3918.06		1	3918		P 286, Neufert
Picinic Area	80ft^2 per family				20	1600		
Total area for youth (outdoor)						65418		
Total area for afterschool program (indoor)						5665		
Total GYM area						12669		
Total outdoor area needed for Friendly House						65418		
Total indoor area needed for Friendly House						31134		

Size Comparison: 2011 MQP vs. Salvatore's Estimate

Department	Present Area	Sergio's estimated area	2011 fhp estimated area	Difference between Sergio's and 2011
Social Service Department				
1. Staff Area				
Food Pantry	0	0	161	161
Private Staff Offices (7)	382	458	904	446
Executive Director Office	0	192	161	-31
Conference Room w. machines(assumptio	0	237	244	7
Staff Breakroom	0	198	258	60
Staff Bathroom Male	146	165	144	-21
Staff bathroom female	198	165	144	-21
Total Staff Area	726	1415	2016	601
2. Socail Service Area				
Classroom (Assumption)	0	880	1715	835
Reception Room	0	180	72	-108
Waiting Area (assumption)	0	279	400	121
Clothing/Laundry Room	0	0	323	323
Total social service area	0	1339	2510	1171
Food Program				
storage room	173	552	900	348
2 door fridges	396.5	0	68	68
2 door freezers		0	23	23
reach in freezer		0	18	18
walk in freezer	185	0	400	400
stand up 4 door oven	0	0	24	24
stove top oven	0	0	33	33
2-bay sinks	0	0	45	45
Desks 4ft x 8ft	0	0	96	96
Total Kitchen Storage	95	375	706	331
Total Kitchen Area	405	540	2665	2125
After School Department				
Staff Lounge	0	180	215	35
Conference Room	0	288	194	-94

storage area for each room	0	0	480	480
Storage Room	255	390	400	10
Total Staff Area	255	858	1289	431
1. After school program				
Homework room	2139	0	1537	1537
Computer room	0	0	480	480
Game room	0	841	1750	909
Multi-purpose room	0	2021	2450	429
Cooking room	0	0	800	800
Boys bathroom	0	132	150	18
Girls bathroom	0	132	135	3
total youth area	2139	3126	7302	4176
2. Teen Activities				
Teen Lounge	0	0	525	525
Game Room	0	0	1800	1800
Quiet Room	0	0	215	215
Mens Bathroom (assumption)	0	132	150	18
Womens Bathroom (assumption)	0	132	135	3
Total Teen area	0	264	2825	2561
3. Sports and Recreation				
Basketball Court	6342	6674	4700	-1974
Walking area and sitting area	0	0	300	300
Storage Room	374	0	400	400
Athletics Office	0	0	215	215
Concessions	0	110	0	-110
Total indoor recreation area	6716	6784	5615	-1169
4. Summer Program				
Sprinkler System Outdoors	0	0	500	500
Grass playing Field (outdoor soccer field)	0	0	59400	59400
Paved Court (outdoor basketball court)	0	0	3918	3918
Picinic Area	0	0	1600	1600
Total area for youth (outdoor)	0	0	65418	65418
Total area for afterschool program (indoor	2394	4248	11416	7168

Total GYM area	6716	6784	5615	-1169
Other				
Administration				
office		396		
office		96		
meeting room		486		
office		84		
office		207		
Assistant director's room		144		
conference room		432		
cubical		144		
staff meeting room		150		
office		330		
director's room		180		
Assistant director's room		120		
Total		2769		
Bathrooms				
showers		165		
Men's bathroom		154		
Men's Locker room		198		
Women's bathroom		274		
women's shower		120		
Women's locker room		138		
bathroom		25		
bathroom		25		
men's bathroom		48		
bathroom		40		
bathroom		40		
bathroom		70		
bathroom		70		
bathroom		70		
bathroom		70		
women's bathroom		48		
bathroom		20		

bathroom		20		
total		1595		
Circulation (without corridors, since it varies)				
Lower lobby		162		
reception		180		
lobby		52		
waiting and reception		726		
Total		1120		
Recreation/educat				
recreation room		1785		
Conference/meeting room		4116		
classroom		924		
classroom		924		
classroom		924		
classroom		924		
library		980		
sitee colocation		99		
sitee colocation		99		
sitee colocation		99		
Total		10874		
Storage				
Storage for furniture		580		
storage for clothing		552		
general storage		28		
general storage		28		
general storage		160		
general storage		352		
general storage		126		
general storage		32		
general storage		369		
general storage		77		
general storage		77		
general storage		180		
Total		2561		

Appendix B: Structural Calculations

Beam Design

Beam 1: W16 x 36 — 36 ft. span

L	36		area	10.6	
ωu	693.2		Fy	50	
Mu	112298.4		Ix	448	
			Ycon	5	
spacing	40		f'c (*1000)	3	
be 1	108				
be 2	480				
be	60	(choose the smaller one from above)			
ΣQn	530				
a	3.46405229		assume a	1	
Y2	3.26797386		assume Y2	4.5	
Mu 1	453	Y2 1		3.5	Larger one table 3-19
Mu 2	433	Y2 2		3	smaller one
φbMn	443.718954				
I 1	795	larger one	table 3-20		
I 2	753	smaller one			
I_{lb}	775.509804				
C1	161		figure 3-2		
ωLL	0.2				
Mu	32.4				
deflection for live load		0.33630773			

Under Construction

ωu(un fact)	331
Mu	53622
Deflection	0.96348314

Beam 2: W16 x 50 — 39 ft. span

L	39		area	14.7		16x50- 39ft
ωu	710		Fy	50		
Mu	134988.75		Ix	659		
			Ycon	5		
spacing	40		f'c (*1000)	3		
be 1	117					
be 2	480					
be	60	(choose the smaller one from above)				
ΣQn	735					
a	4.80392157		assume a	1		
Y2	2.59803922		assume Y2	4.5		
Mu 1	550	Y2 1		3	Larger one	table 3-19
Mu 2	525	Y2 2		2.5	smaller one	
ϕbMn	529.901961					
I 1	1400	larger one	table 3-20			
I 2	1330	smaller one				
I_{lb}	1343.72549					
C1	161		figure 3-2			
ωLL	0.2					
Mu	38.025					
deflection for live load		0.26733881				

Under Construction

ωu(un fact)	345
Mu	65593.125
Deflection	0.94032124

Girder Design

ωu	2258					
Mu	176406.25					
L	25					
				Girder 1		
q	529			**W16 x 36**		
a	0.88654265					
Y2	4.55672867					
Mu 1	513	Y2 1	5	Larger one	table 3-19	
Mu 2	493	Y2 2	4.5	smaller one		
ϕbMn	495.269147			area		10.6
				Fy		50
I 1	1260	larger one	table 3-20	Ix		448
I 2	1200	smaller one		Ycon		5
				f'c (*1000)		3
I_{lb}	1206.80744					
C1	161		figure 3-2			
ωLL	0.78					
Mu	60.9375					
deflection for live load		0.19602019				
Under Construction						
ωu(un fact)	1112.4					
Mu	25368273					
Deflection	0.75253642					

ωu	4272			
Mu	333750			
L	25			
			Girder 2	
			W18 x 50	
q	733			
a	0.63877996			
Y2	4.68061002			
Mu 1	770	Y2 1	5 Larger one	table 3-19
Mu 2	742	Y2 2	4.5 smaller one	
ϕbMn	752.114161		area	14.7
			Fy	50
I 1	2240	larger one table 3-20	Ix	800
I 2	2140	smaller one	Ycon	5
			f'c (*1000)	3
I_{lb}	2176.122			
C1	161	figure 3-2		
ωLL	1.5			
Mu	117.1875			
deflection for live load		0.20905097		
Under Construction				
ωu(un fact)	2080			
Mu	48987311.4			
Deflection	0.78798491			

ωu	4048					
Mu	316250					
L	25					
				Girder 3		
				W18 x 46		
q	677					
a	0.58997821					
Y2	4.70501089					
Mu 1	712	Y2 1	5	Larger one	table 3-19	
Mu 2	687	Y2 2	4.5	smaller one		
ϕbMn	697.250545			area		14.7
				Fy		50
I 1	2040	larger one	table 3-20	Ix		800
I 2	1950	smaller one		Ycon		5
				f'c (*1000)		3
I_{lb}	1986.90196					
C1	161		figure 3-2			
ωLL	1.44					
Mu	112.5					
deflection for live load		0.21980128				
Under Construction						
ωu(un fact)	1953					
Mu	46307062.7					
Deflection	0.83131727					

Girder 4
W16 x 31

ωu	2035
Mu	158984.375
L	25
q	456
a	0.82788671
Y2	4.58605664

Mu 1	443	Y2 1	5	Larger one	table 3-19
Mu 2	426	Y2 2	4.5	smaller one	

ϕbMn	428.925926

area	9.13
Fy	50
Ix	375
Ycon	5
f'c (*1000)	3

I 1	1140	larger one	table 3-20
I 2	1080	smaller one	

I_{lb}	1090.3268	
C1	161	figure 3-2
ωLL	0.78	
Mu	60.9375	
deflection for live load		0.21696121

Under Construction

ωu(un fact)	984.3
Mu	22622177.2
Deflection	0.79550108

Column Design

Type of load	Loads (psf)*
Roof	
Dead load total	**47.10**
Soil[1]	30.10
Plants	2.00
Conventional Roof	15.00
Live load	**20.00**
Snow Load	**55.00**
Floor	
Dead load total	**55.00**
Concrete/deck[2]	35.00
MEP	5.00
Ceiling	3.00
Partition	12.00
Apartment live load	**40.00**

1. Soil type: Stalite Extensive Mix. Saturated Density: 91 lb/ft^3. Depth of soil: 4 inches.
   Unit weight: 91 lb/ft^3 x (4 in. / 12) = 30.1 lb/ft^2
2. Light weight concrete on steel deck.

*Some of the loads were assumptions, and require further detailed analysis.

Factored loads for roof and floor are listed below:

Roof: $1.2D + 1.6(L_r/S/R) + (0.5L/0.8W) = 1.2*47.1 + 1.6*55 = 144.52\,psf$

Floor: $1.2D + 1.6L + 0.5(L_r/S/R) = 1.2*55 + 1.6*40 = 130\,psf$

Roof and Floor Dead Load: 62psf (including weight of beams and girders)

Total Dead Load per Unit Area around Each Column: 62 x 3 = 186psf

Floor Live Load: 40psf for each floor

Total Live Load per Unit Area around Each Column: 40 x 2 = 80psf

Snow Load: 55psf

Total Load per unit area used: $load\_per\_unit = 1.2D + 1.6L + 0.5S = 378.7\,psf$

Design for Corner Columns:

Tributary area: Area=243.75 ft^2

Point Load Acts on the Column: $P_u = load\_per\_unit \times Area = 378.7 \times 243.75 = 92.31kip$

Assumption (according to AISC Table 4-22) $\frac{kl}{r} = 50 \quad \Phi F_{cr} = 37.5ksi$

Column Cross Section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{92.31}{37.5} = 2.85in^2$

Choose A Column According To the Area Above: HSS 4 x 3 x ¼ A = 2.91 in^2 r_x =1.74 r_y = 1.16

$$\frac{kl}{r} = \frac{1 \times 12 \times 12}{1.16} = 124$$

Look for ΦF_{cr} Value From AISC Table 4-22: ΦF_{cr}=14.7ksi

Calculate The Minimum Required Column cross section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{92.31}{14.7} = 6.28in^2$

Since 6.28 in^2 > 2.91 in^2, Seek For A new Column From AISC Table 1-11:

HSS 5 x 4 x 3/8 A = 5.48 in^2 r_x =1.81 r_y = 1.52 $\frac{kl}{r} = \frac{1 \times 12 \times 12}{1.52} = 94.74$

Look For ΦF_{cr} Value From AISC Table 4-22: ΦF_{cr}=23.3ksi

Calculate The Minimum Required Column cross section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{92.31}{23.3} = 3.96 in^2$

Since 3.96 in^2 < 5.48 in^2, HSS 5 x 4 x 3/8 Satisfies the Scenario.

Design for Edge Columns:

Tributary Area: Area=487.5 ft^2

Point Load Acts on the Column: $P_u = load\_per\_unit \times Area = 378.7 \times 487.5 = 184.62 kip$

Assumption (According to AISC 4-22): $\frac{kl}{r} = 100 \quad \Phi F_{cr} = 21.7 ksi$

Column Cross Section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{184.62}{21.7} = 8.51 in^2$

Choose A Column According to the Area Above From AISC Table 1-11: HSS 10 x 4 x 3/8 A = 8.97 in^2 r_x =3.41 r_y = 1.64

$$\frac{kl}{r} = \frac{1 \times 12 \times 12}{1.64} = 87.8$$

Look For ΦF_{cr} Value from AISC Table 4-22 ΦF_{cr}=25.5

Calculate The Minimum Required Column cross section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{184.62}{25.5} = 7.24 in^2$

Since 7.24 in^2 < 8.97 in^2, HSS 10 x 4 x 3/8 Satisfies the Scenario.

Design for Interior Columns:

Tributary Area: 937.5 ft^2

Point Load Acts on the Column: $P_u = load\_per\_unit \times Area = 378.7 \times 937.5 = 355kip$

Assumption (According to AISC 4-22): $\frac{kl}{r} = 50 \quad \Phi F_{cr} = 37.5ksi$

Column Cross Section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{355}{37.5} = 9.47in^2$

Choose A Column According To The Area Above From AISC Table 1-1: W14 x 43 A = 12.6 in^2 r_x =5.82 r_y = 1.89

$$\frac{kl}{r} = \frac{1 \times 12 \times 12}{1.89} = 76.19$$

Look For ΦF_{cr} Value From AISC Table 4-22 ΦF_{cr}=29.5

Calculate The Minimum Required Column cross section Area: $A = \frac{P_u}{\Phi F_{cr}} = \frac{355}{29.5} = 12.0in^2$

Since 12.0 in^2 < 12.6 in^2, This Column Satisfies the Scenario.

Footing Designs:

Soil Bearing Capacity: 40ksf (Assume the whole site is shale)

Corner Footing:

Point Load Applied To Footing by Column (With Column weight):

$$P = P_u + factored\_column\_weight = 92.31 + 1.2 \times 19.75 \times 40/1000 = 93.26 kip$$

Area of Footing: $A = \dfrac{P}{Soil\_Bearing\_Capacity} = \dfrac{93.26}{40} = 2.33 ft^2$

Footing Dimension: $w, l = \sqrt{A} = \sqrt{2.33} = 1.526 ft = 18.3 in$

<u>Footing sizes: 18.3in x 18.3in</u>

Edge Footing:

Point Load Applied To Footing by Column (With Column weight):

$$P = P_u + factored\_column\_weight = 184.62 + 1.2 \times 32.51 \times 40/1000 = 186.18 kip$$

Area of Footing: $A = \dfrac{P}{Soil\_Bearing\_Capacity} = \dfrac{186.18}{40} = 4.65 ft^2$

Footing Dimension: $w, l = \sqrt{A} = \sqrt{4.65} = 2.16 ft = 26 in$

<u>Footing sizes: 26in x 26in</u>

Interior Footing:

Point Load Applied To Footing by Column (With Column weight):

$$P = P_u + factored\_column\_weight = 355 + 1.2 \times 43 \times 40/1000 = 357.1kip$$

Area of Footing: $A = \dfrac{P}{Soil\_Bearing\_Capacity} = \dfrac{357.1}{40} = 8.93\,ft^2$

Footing Dimension: $w,l = \sqrt{A} = \sqrt{8.93} = 2.98\,ft = 36in$

<u>Footing sizes: 36in x 36in</u>

Appendix C: Detail Drawings

AREA OF EXISTING PROPERIES	
PROPERTY	AREA (FT^2)
LAND OWNED BY FRIENDLY HOUSE	30,255
LAND OWNED BY CITY OF WORCESTER	89,269
POTENTIAL LAND TO BE ACQUIRED BY FRIENDLY HOUSE	21,000
FRIENDLY HOUSE BUILDING FOOTPRINT	14,980
FRIENDLY HOUSE PARKING LOTS	11,588

LEGEND:

- LAND OWNED BY FRIENDLY HOUSE
- LAND OWNED BY CITY OF WORCESTER
- POTENTIAL LAND TO BE ACQUIRED BY FRIENDLY HOUSE
- FRIENDLY HOUSE BUILDING BOUNDARY
- FRIENDLY HOUSE PARKING BOUNDARY
- BUILDINGS LOCATED IN POTENTIALLY ACQUIRED LAND

FRIENDLY HOUSE
EXISTING LOT BOUNDARIES

Figure 41: Existing Lot Boundaries

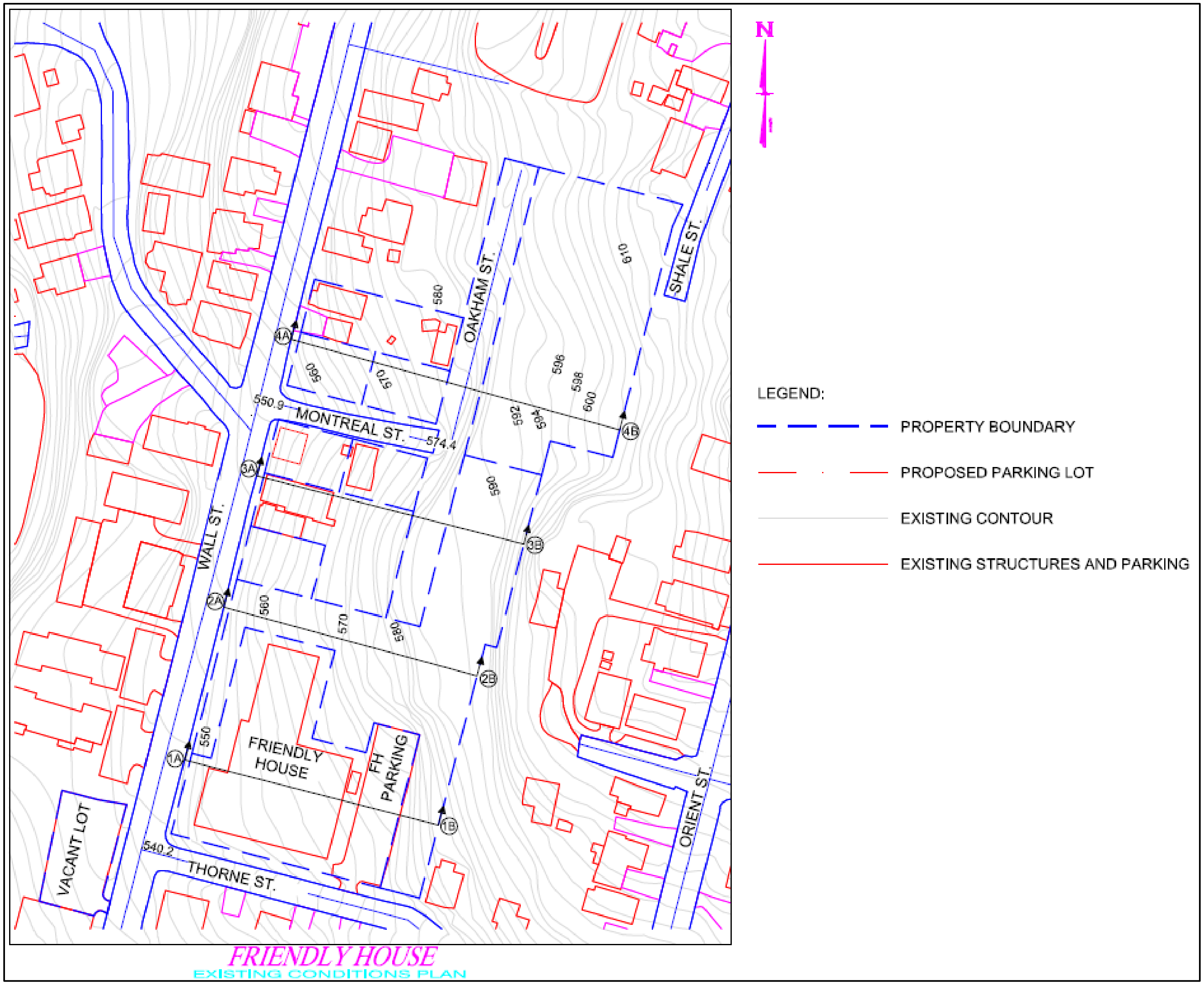


Figure 42: Existing Conditions Plan

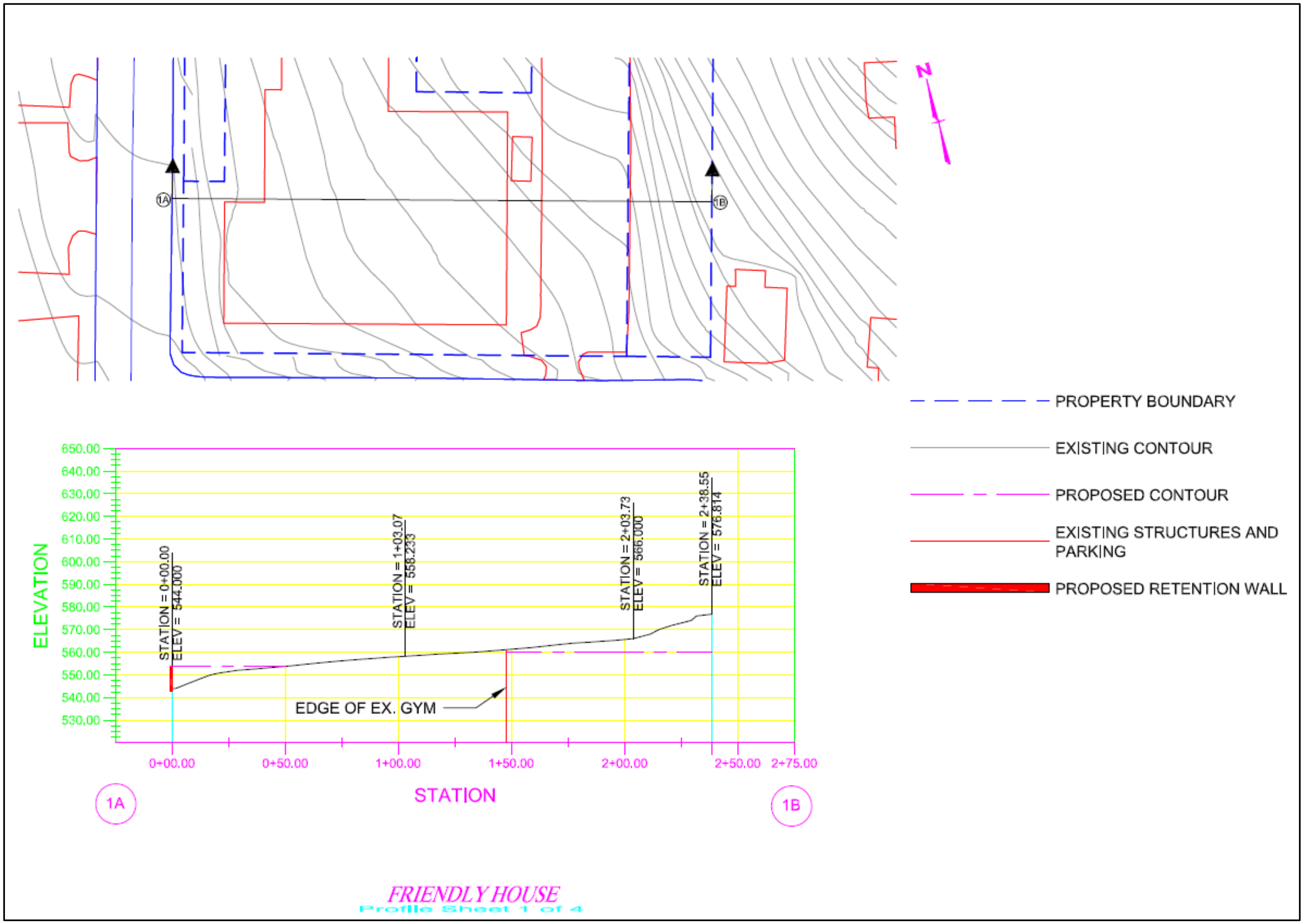


Figure 43: Front of Friendly House Profile

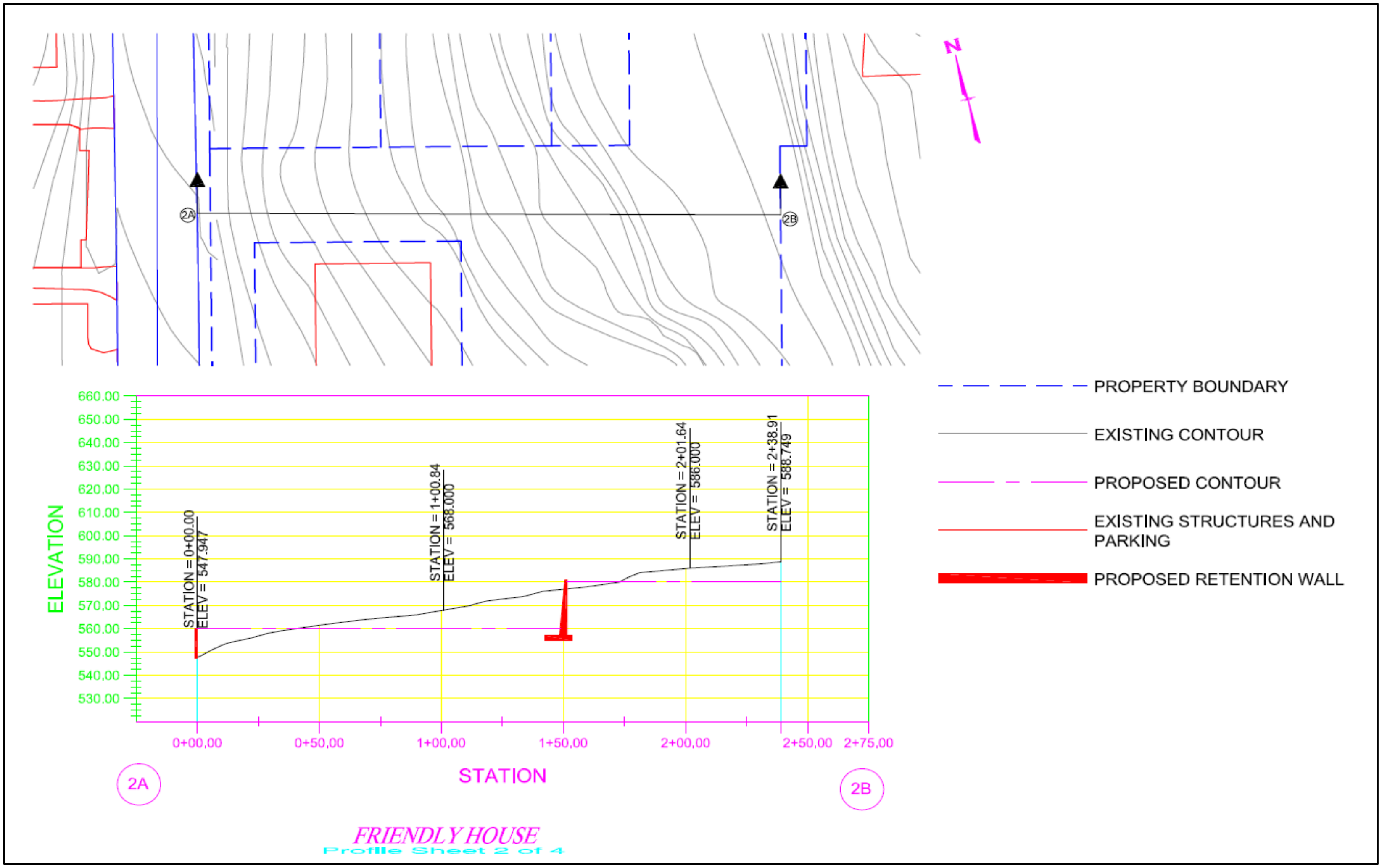


Figure 44: Mid Friendly House Profile

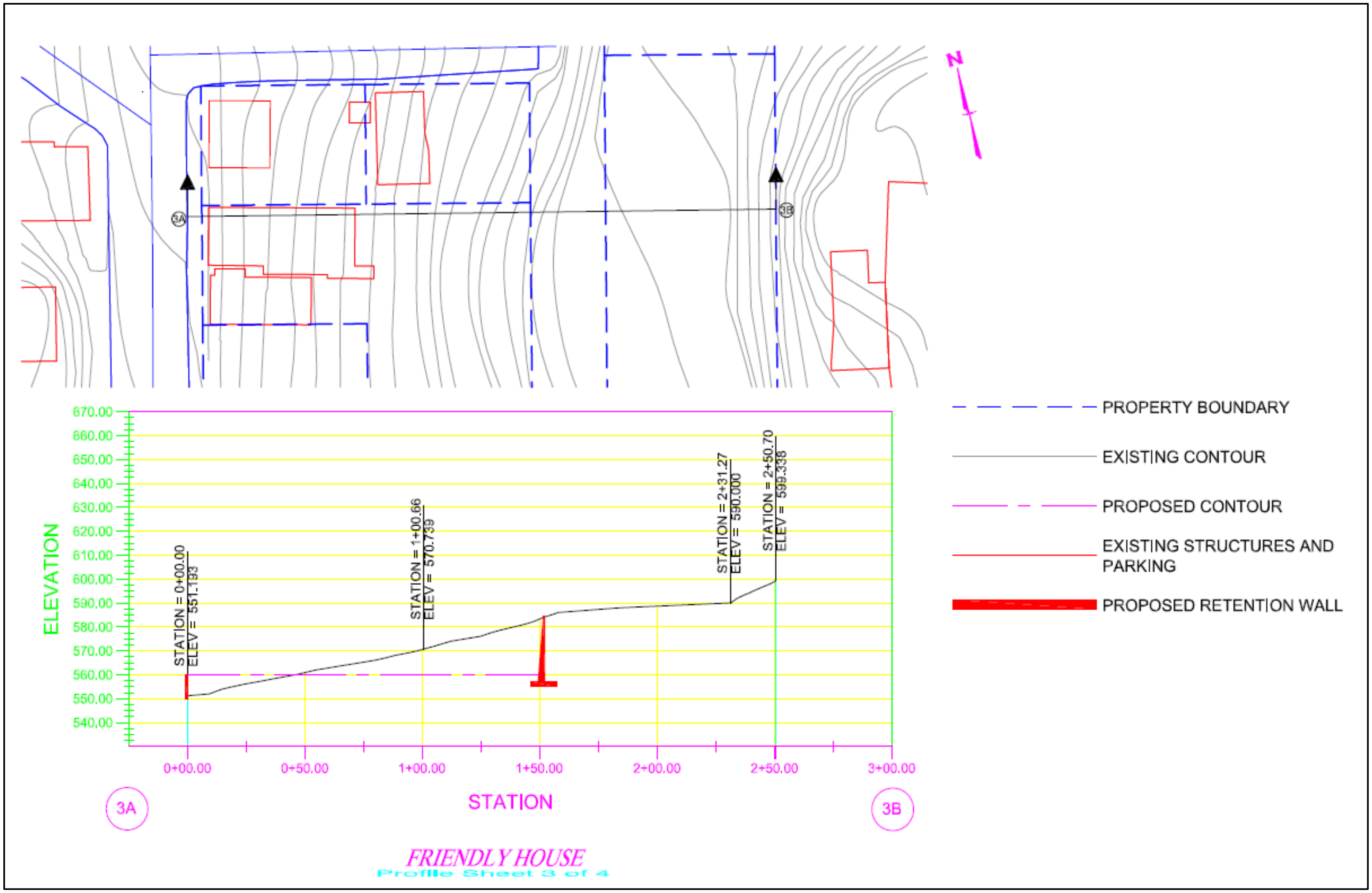


Figure 45: Montreal Street Profile

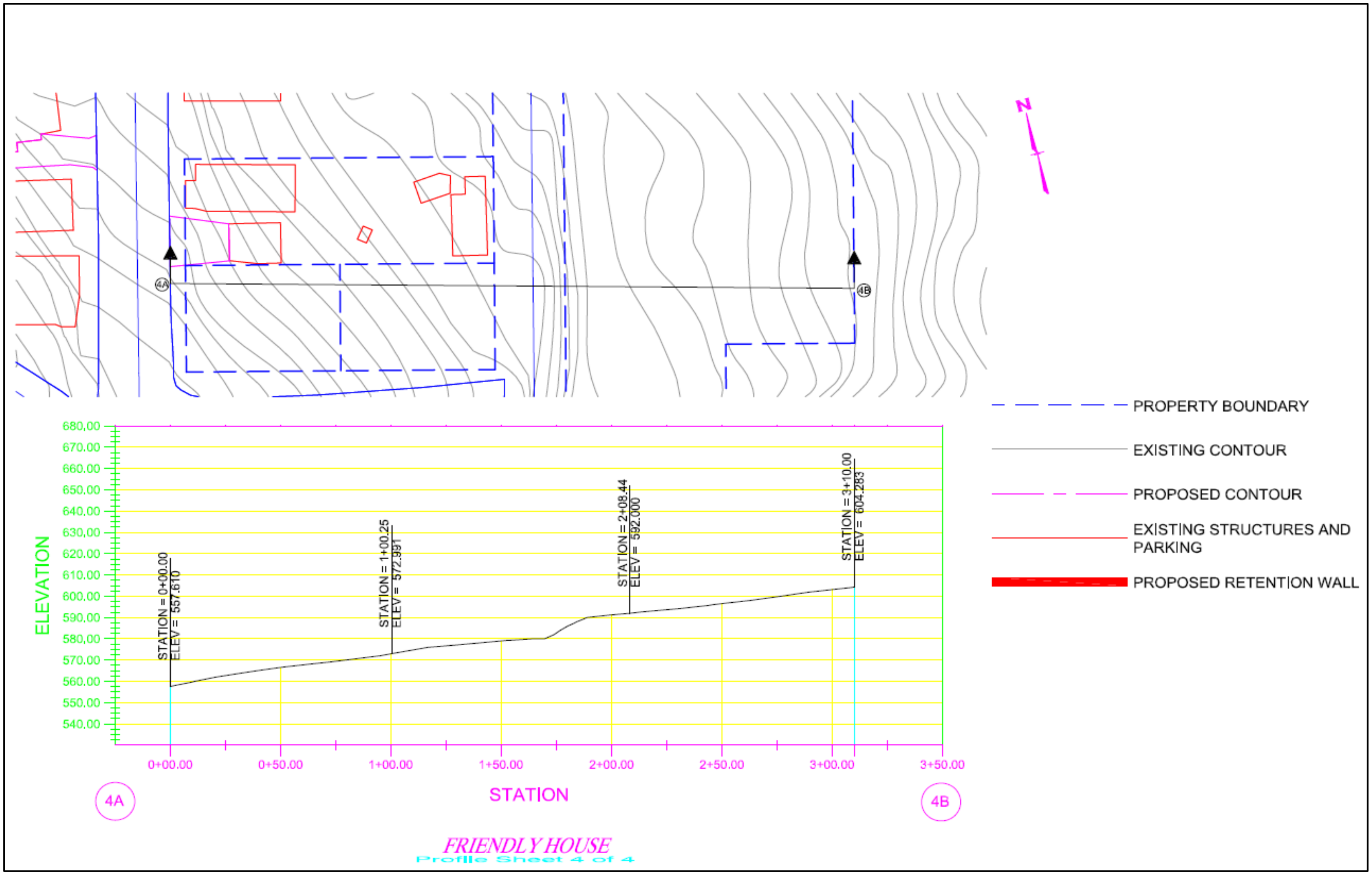


Figure 46: Shale Street Profile

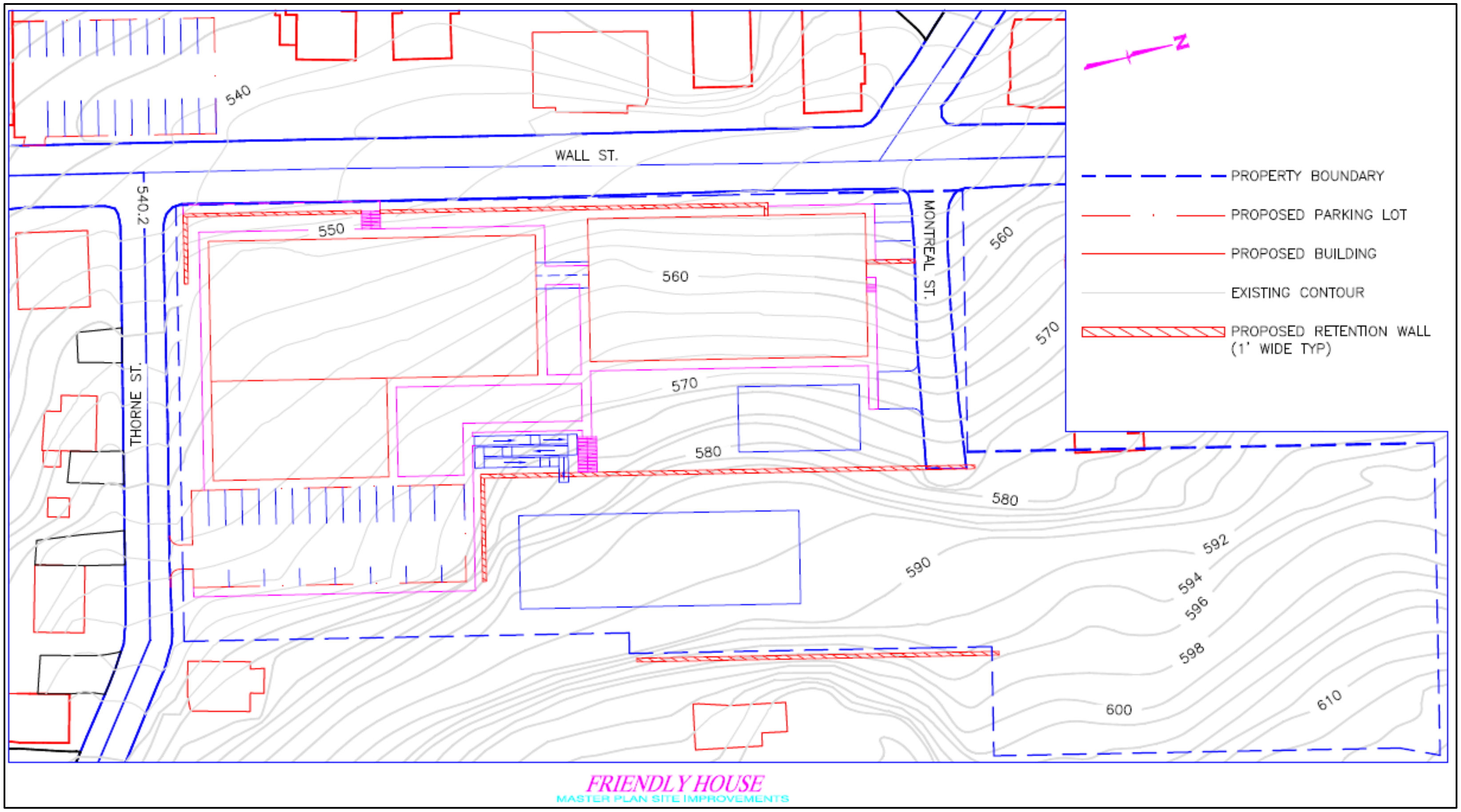


Figure 47: Master Plan Site Improvements

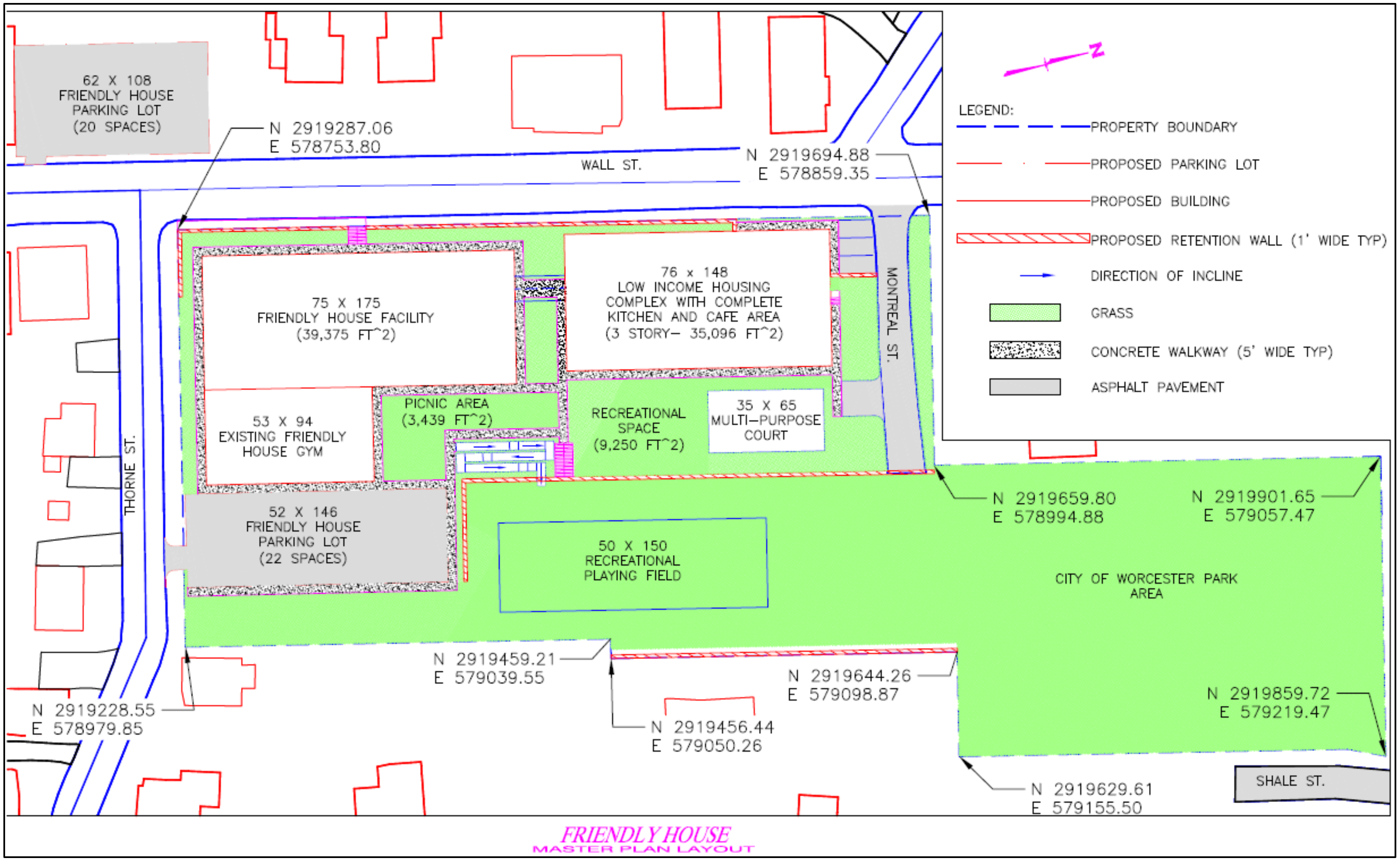


Figure 48: Master Plan Layout

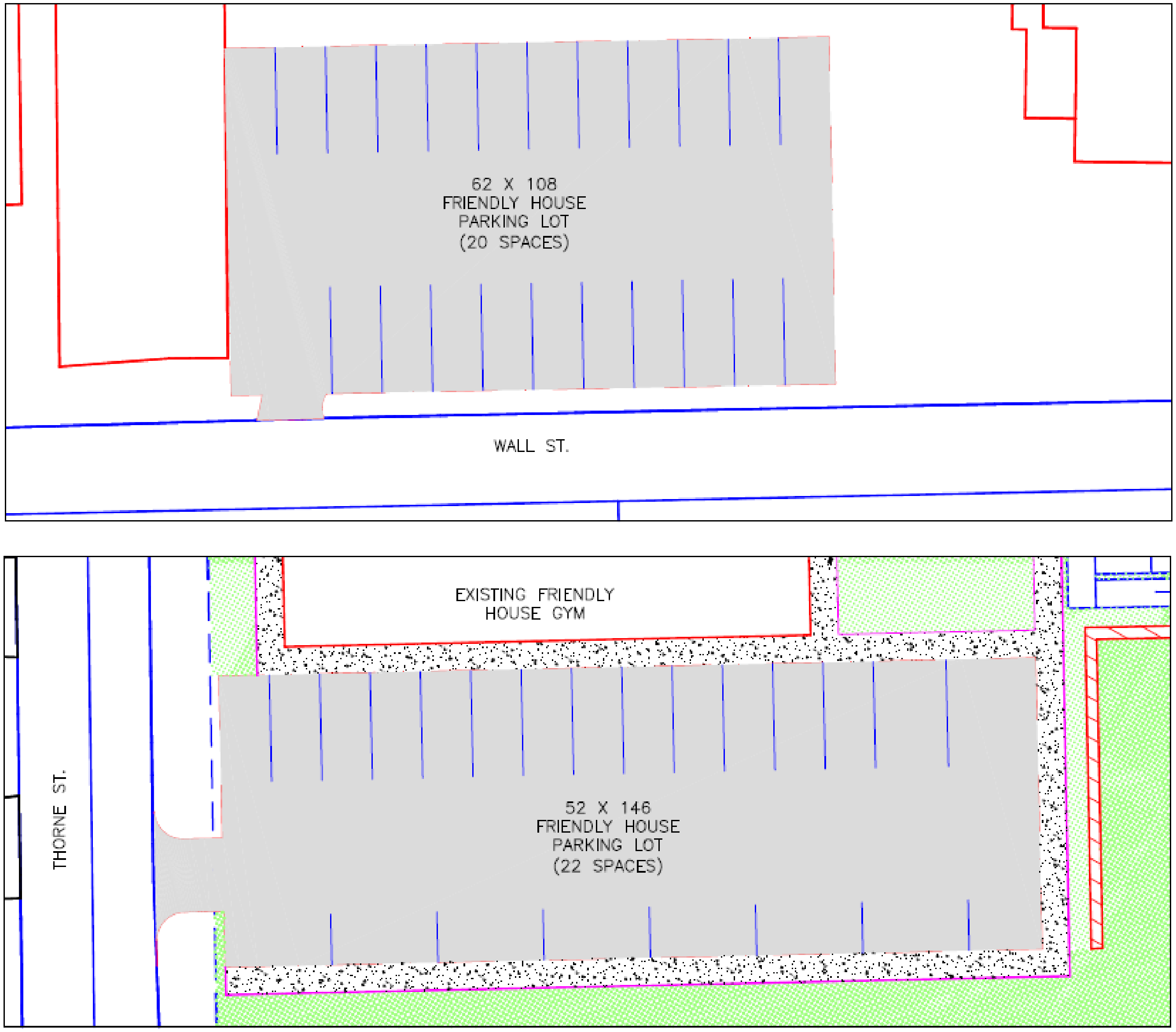


Figure 49: Parking Layout

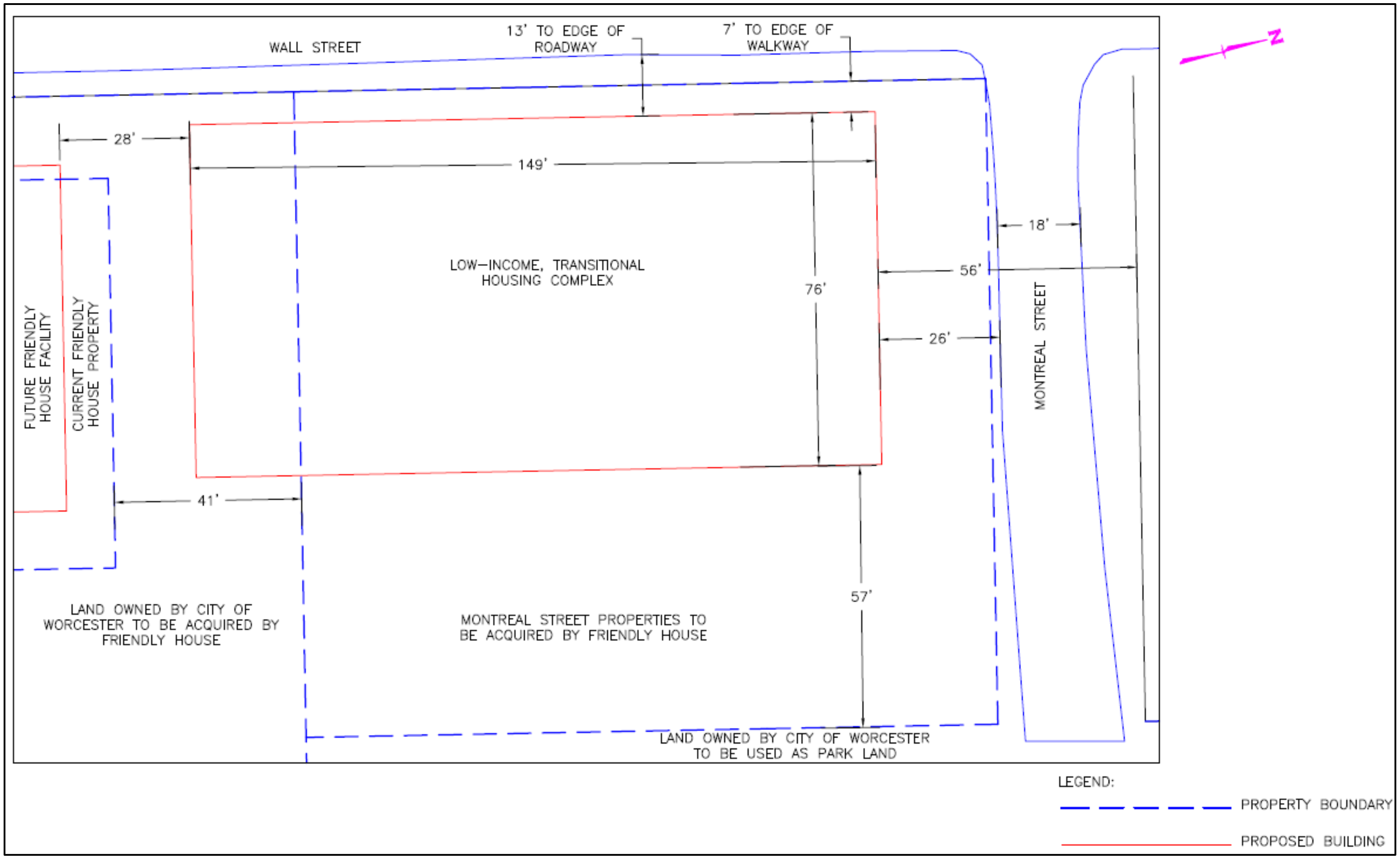


Figure 50: Building Setback

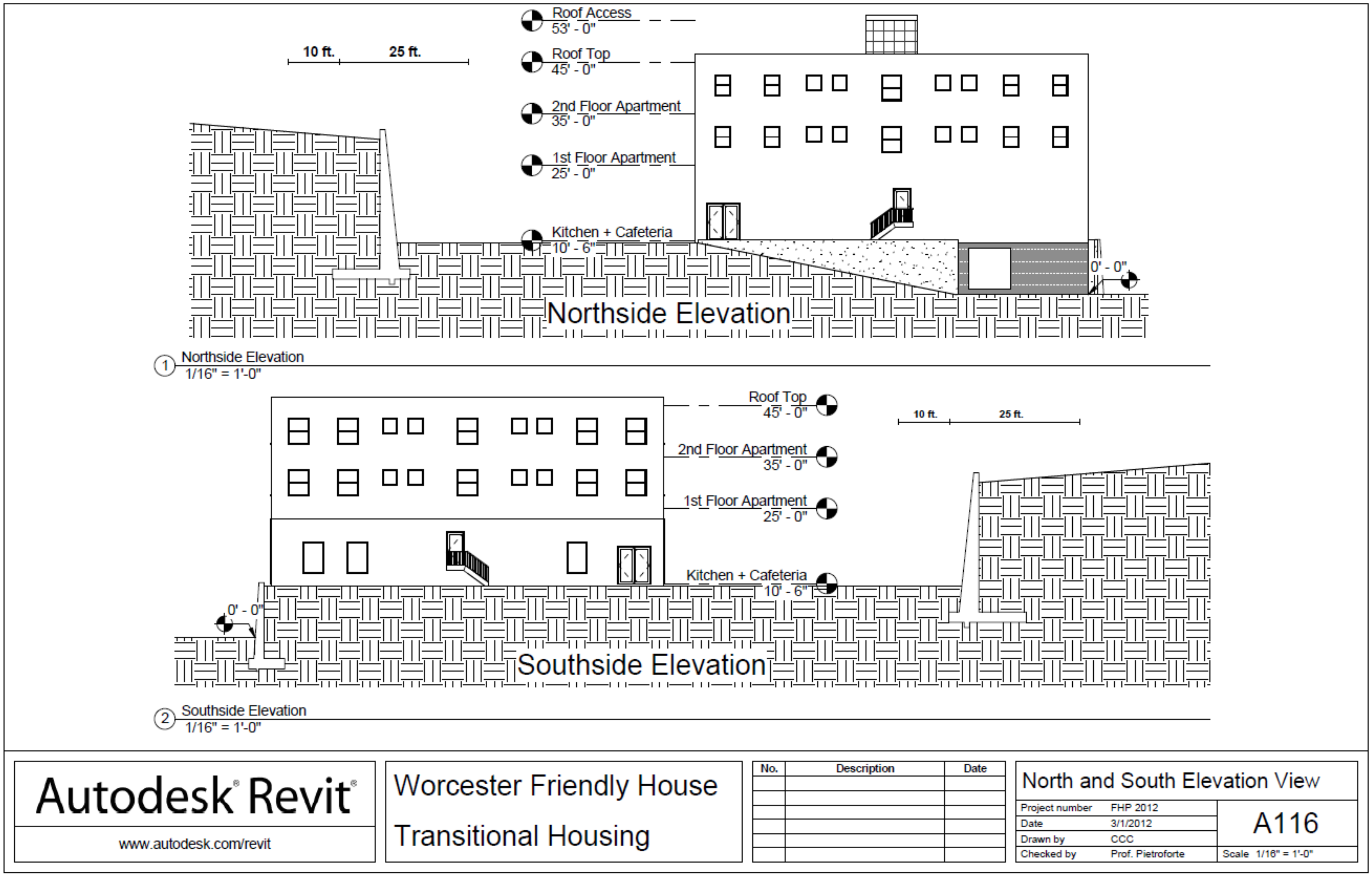


Figure 51: North & South Elevation

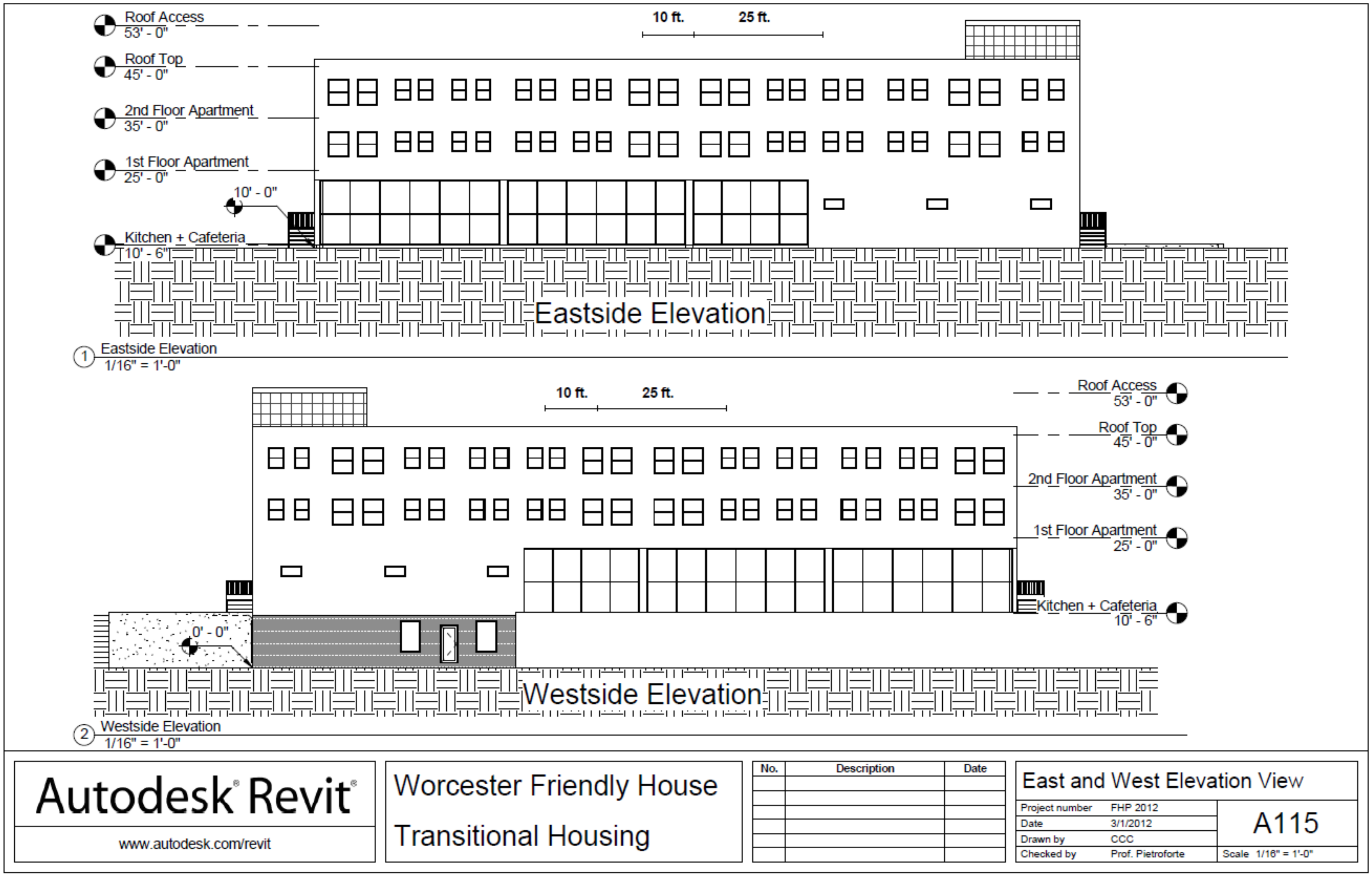


Figure 52: East & West Elevation

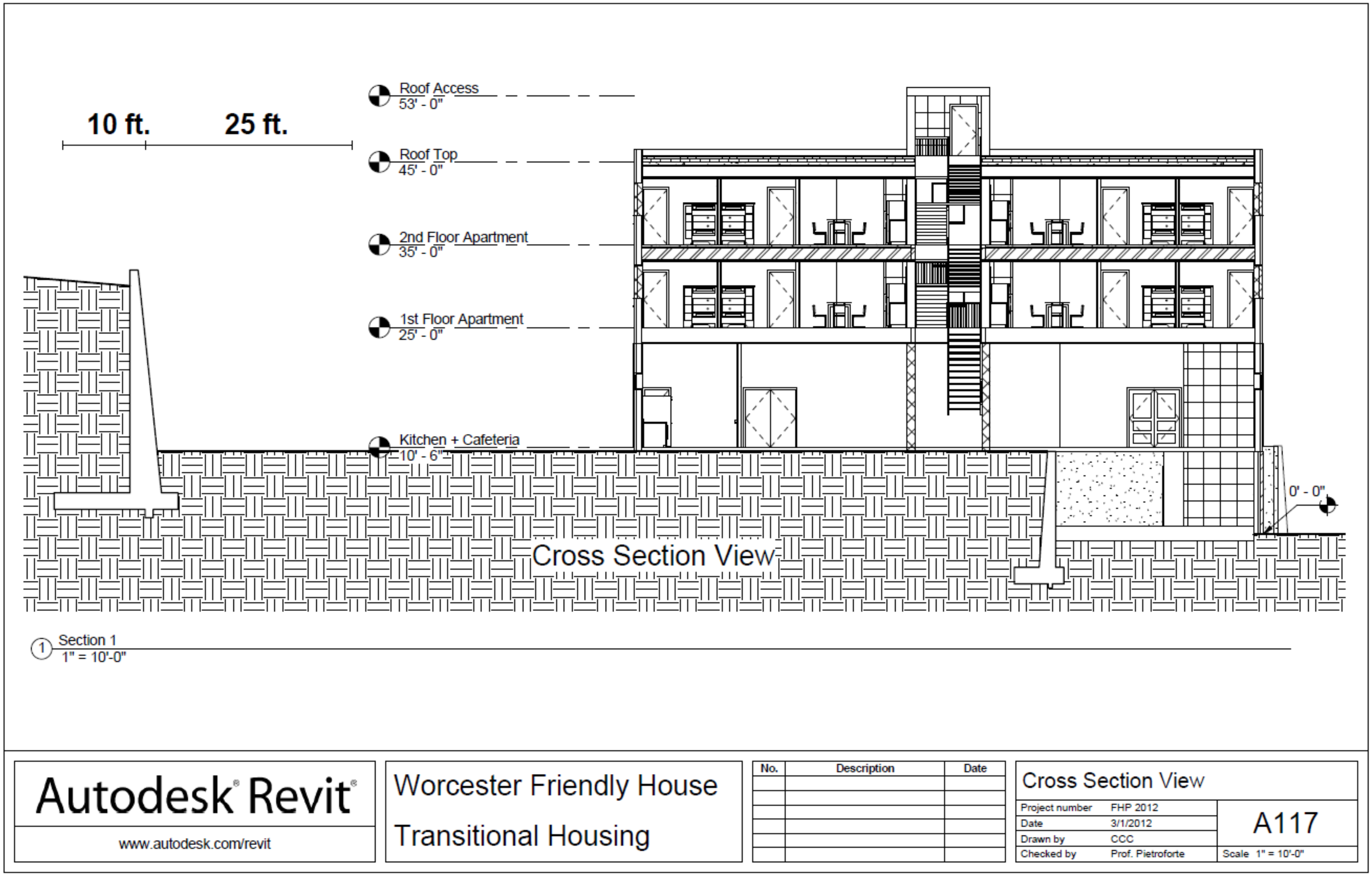


Figure 53: Cross Section

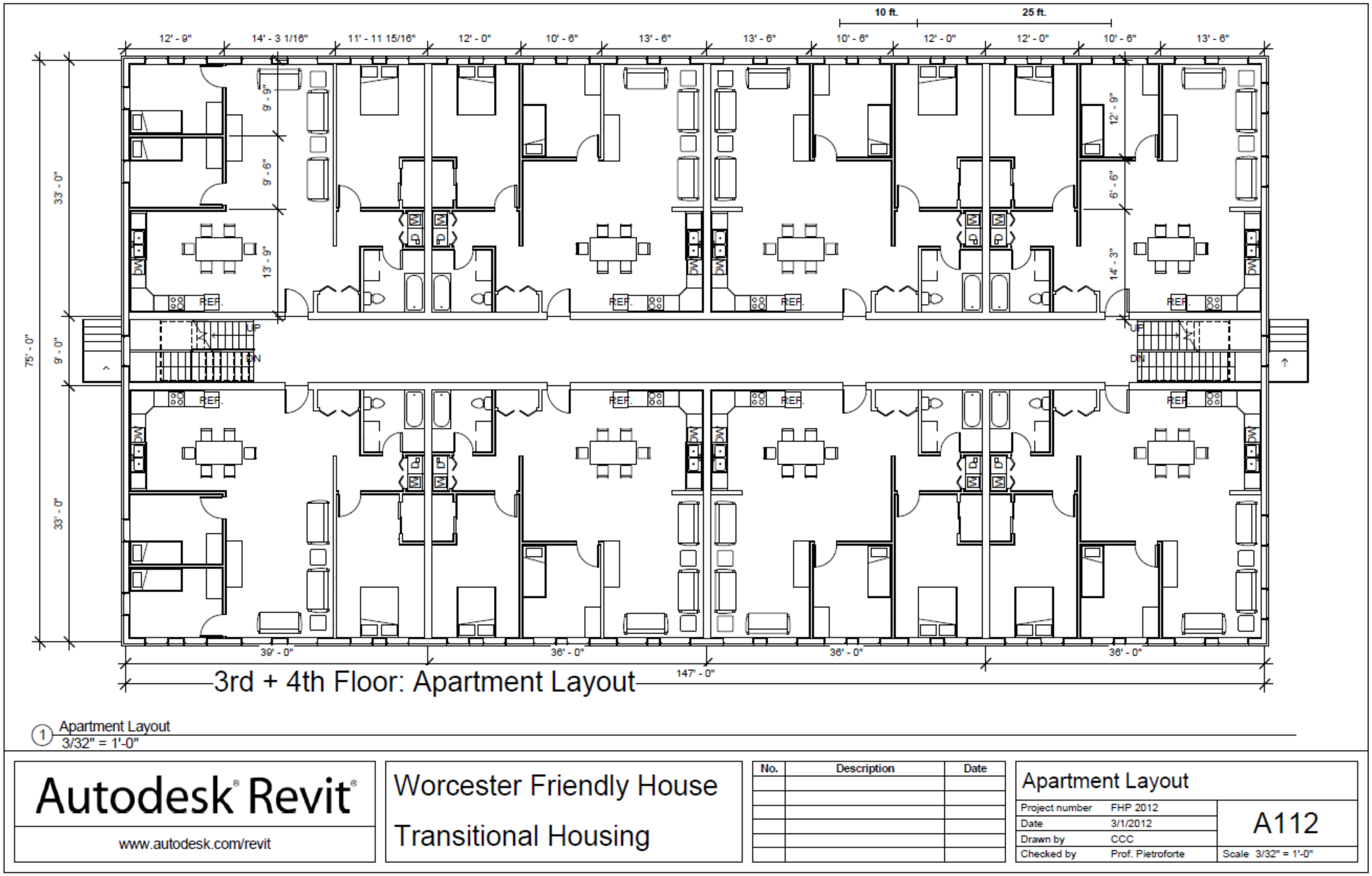
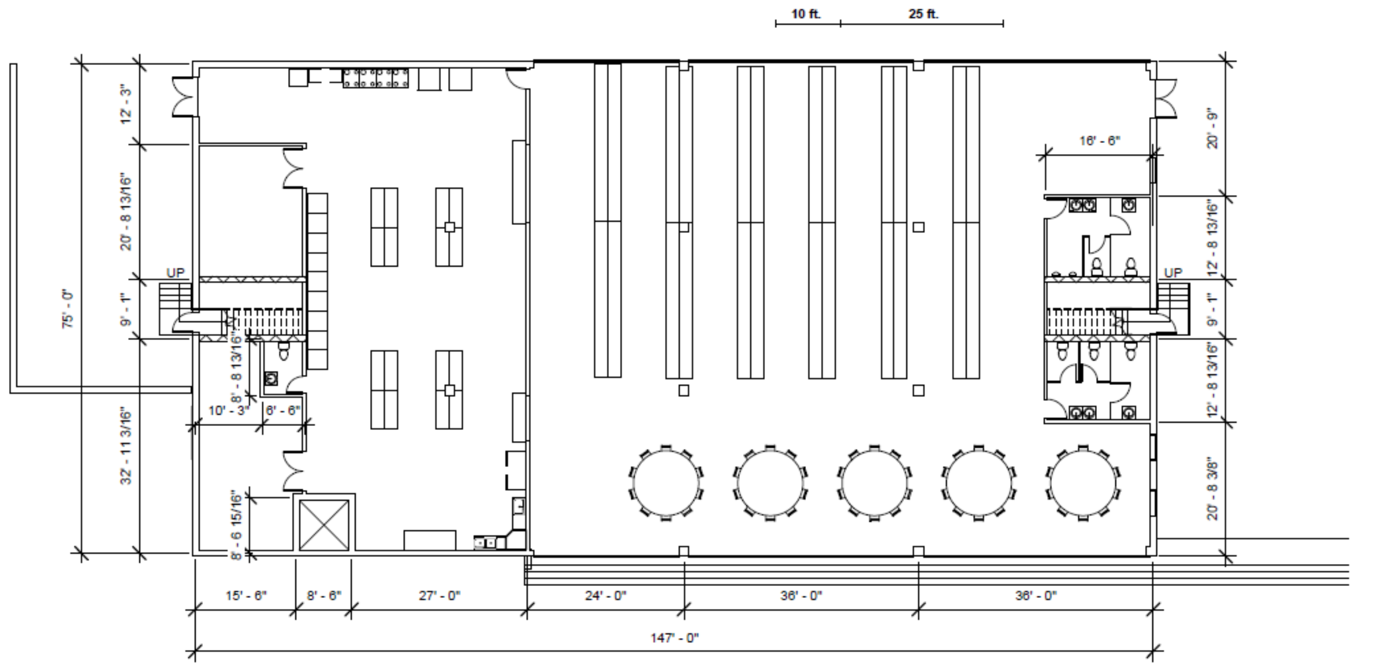


Figure 54: Apartment Layout



1st Floor: Kitchen + Cafeteria Layout

1 Kitchen + Cafeteria
1/16" = 1'-0"

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Worcester Friendly House
Transitional Housing

No.	Description	Date

Kitchen & Cafeteria Layout

Project number	FHP 2012	A113
Date	3/1/2012	
Drawn by	CCC	
Checked by	Prof. Pietroforte	Scale 1/16" = 1'-0"

Figure 55: Kitchen & Cafeteria Layout

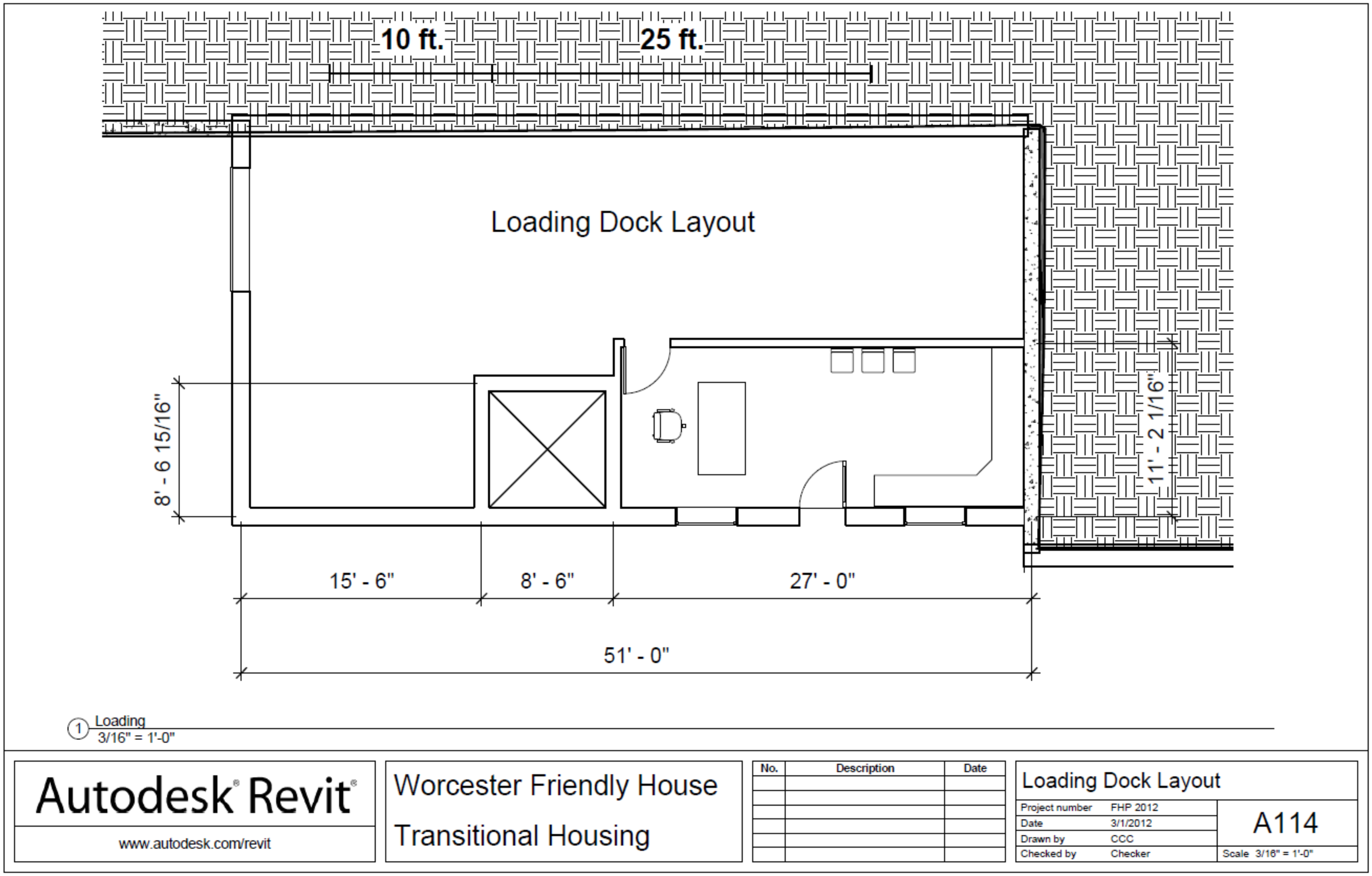


Figure 56: Loading Dock Layout

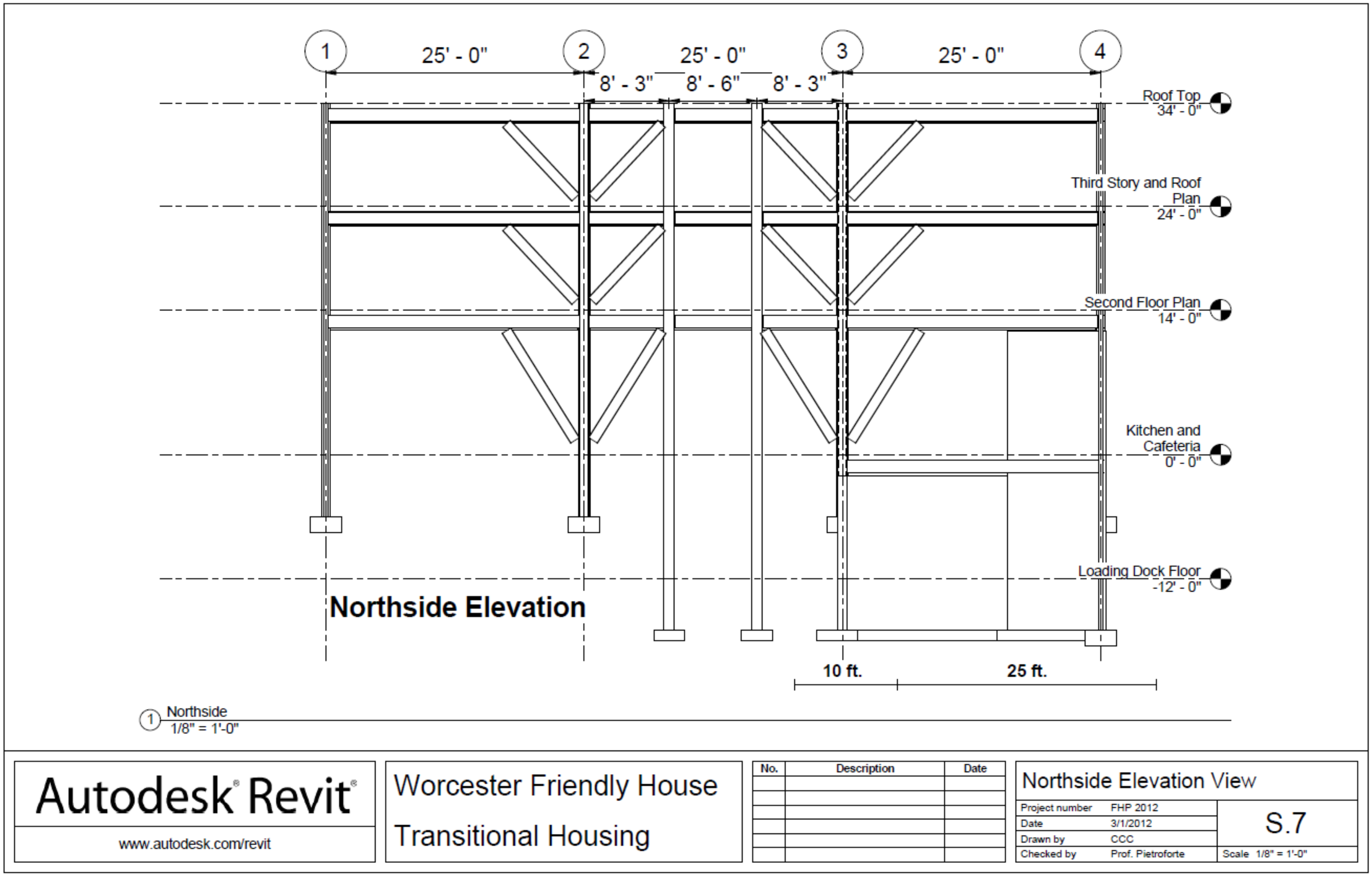


Figure 57: North Elevation Structural View

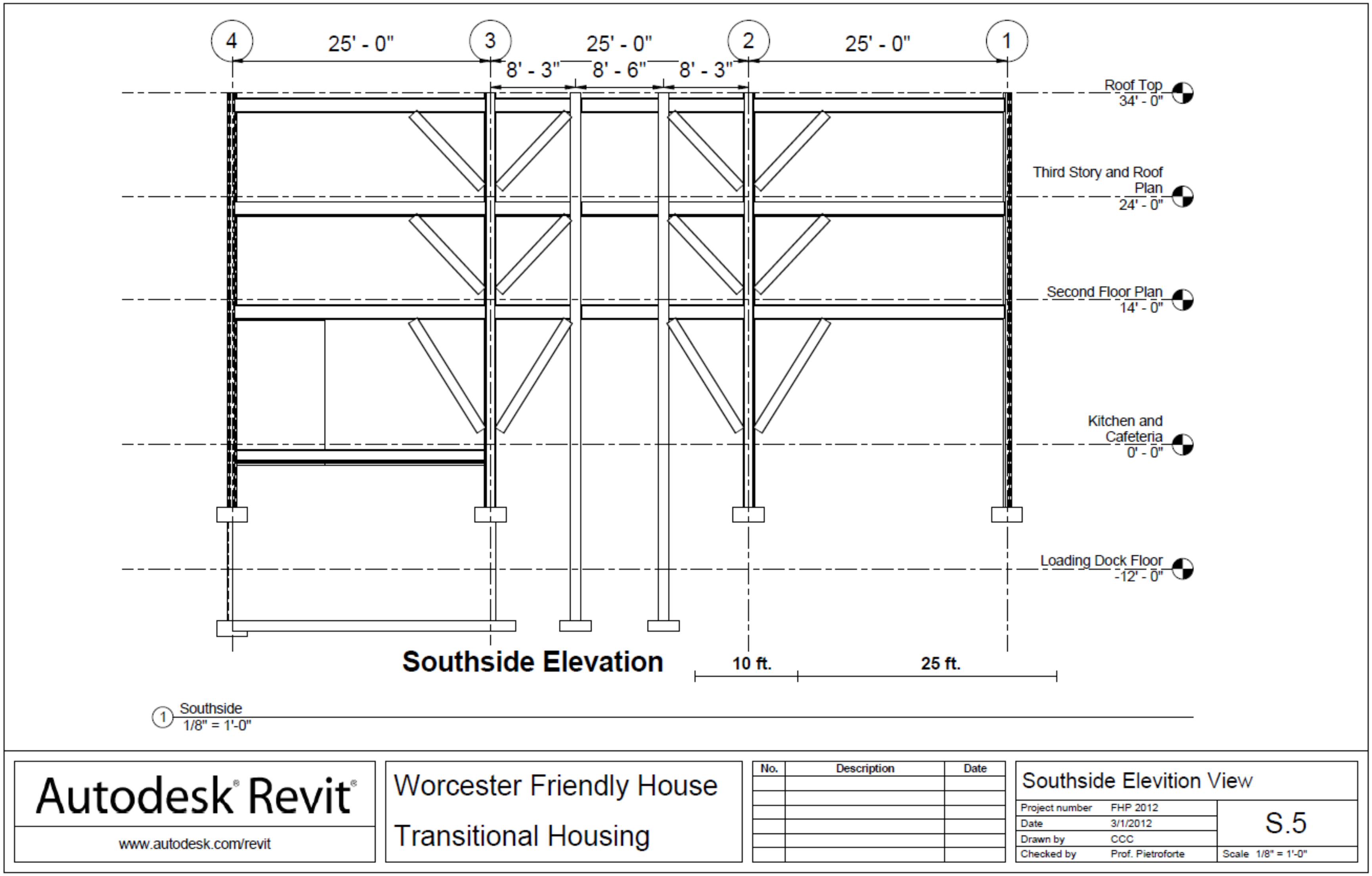


Figure 58: South Elevation Structural View

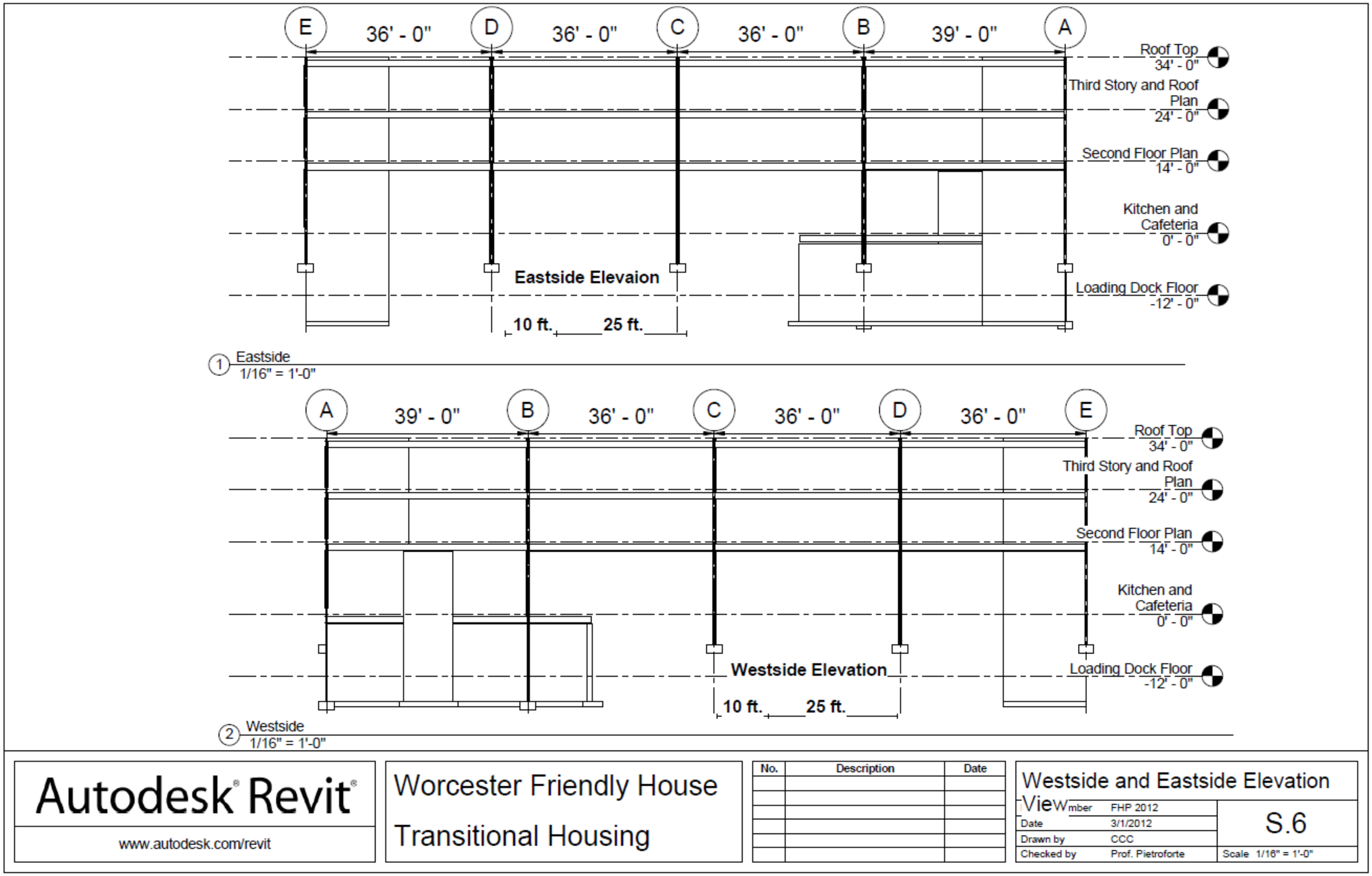


Figure 59: East & West Elevation Structural View

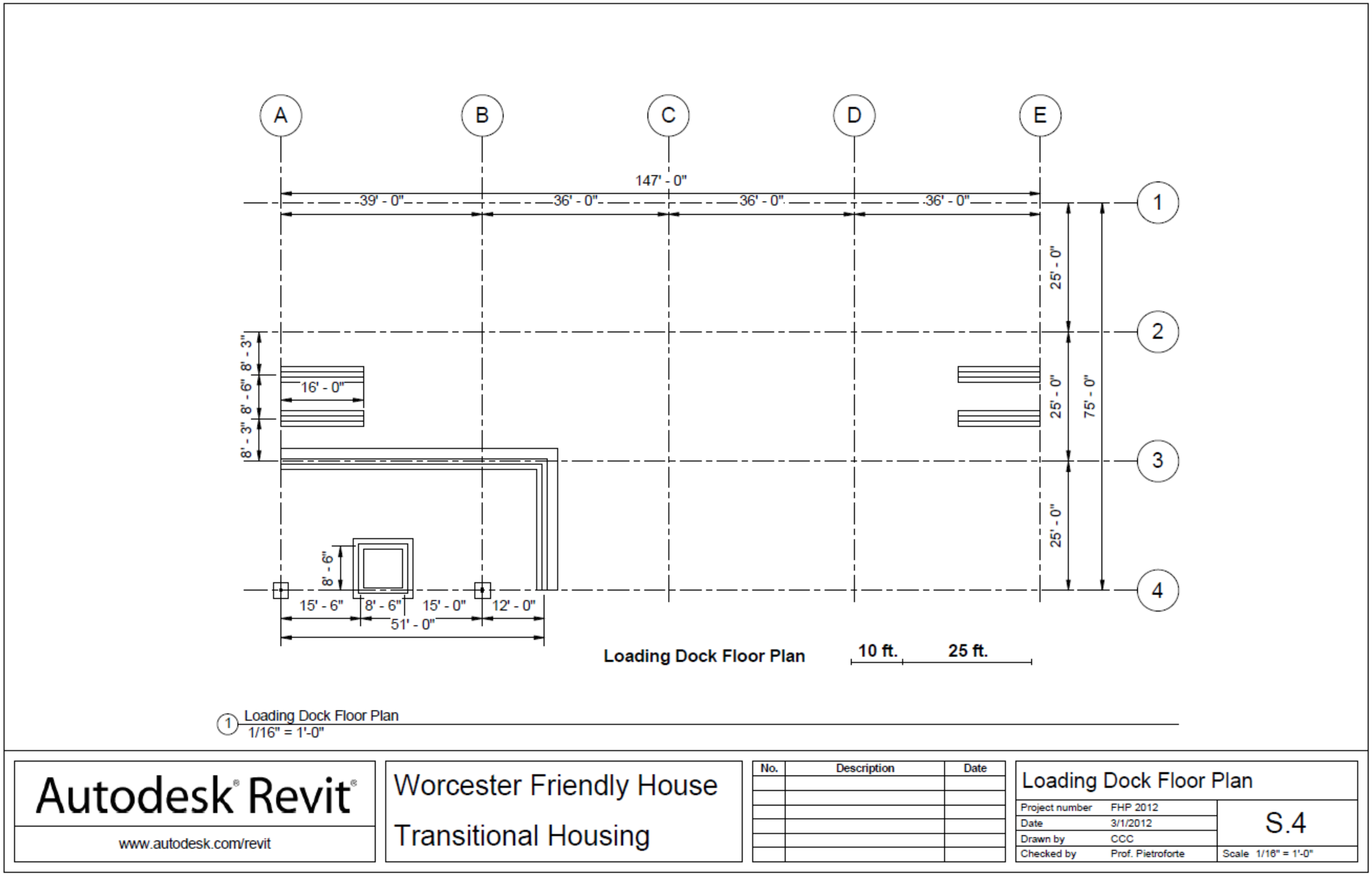
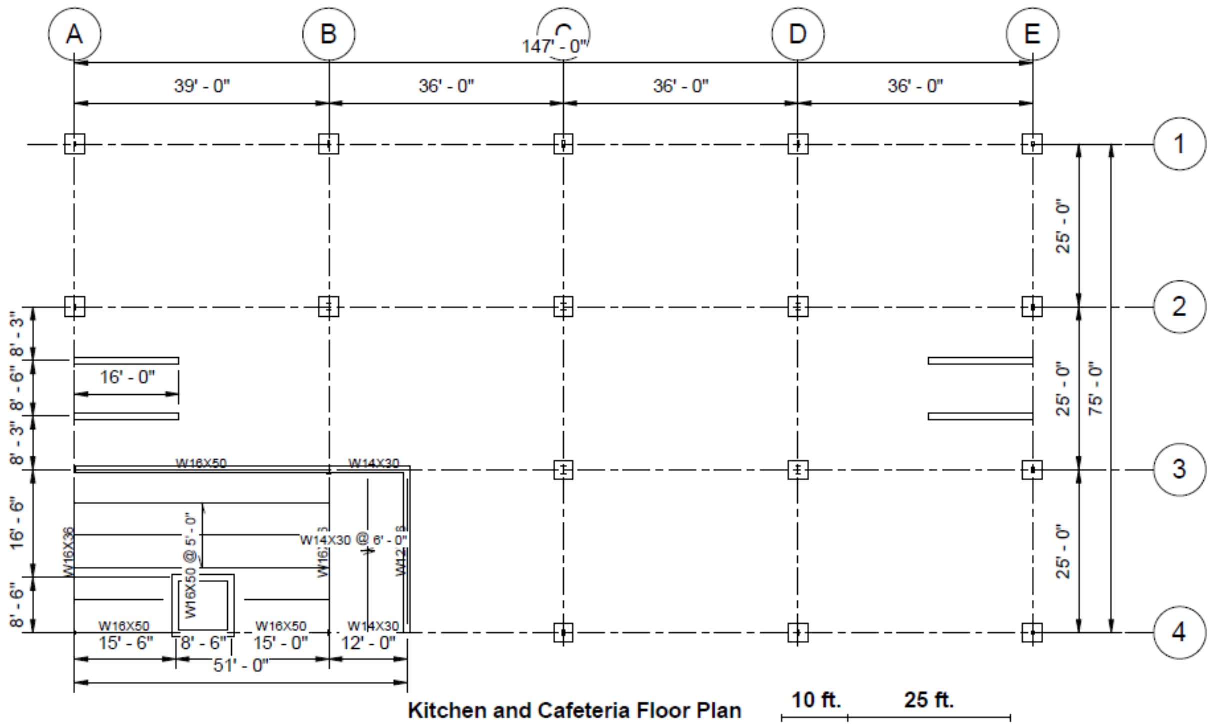


Figure 60: Loading Dock Structural Layout



1 Kitchen and Cafeteria Plan
1/16" = 1'-0"

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No.	Description	Date

Kitchen and Cafeteria Floor Plan

Project number	FHP 2012	S.3
Date	3/1/2012	
Drawn by	CCC	
Checked by	Prof. Pietroforte	Scale 1/16" = 1'-0"

Figure 61: Kitchen & Cafeteria Structural Layout

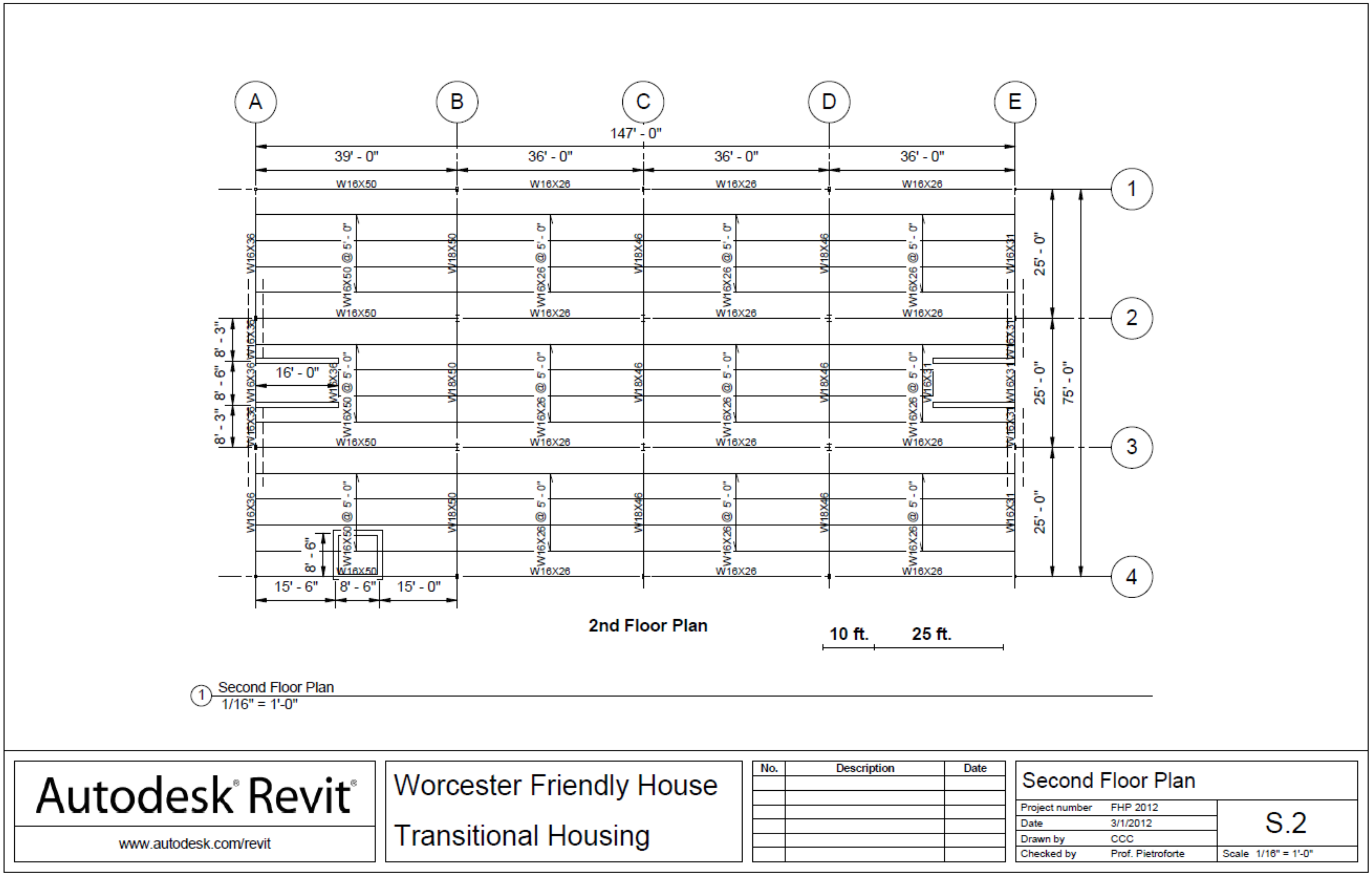


Figure 62: Second Floor Structural Layout

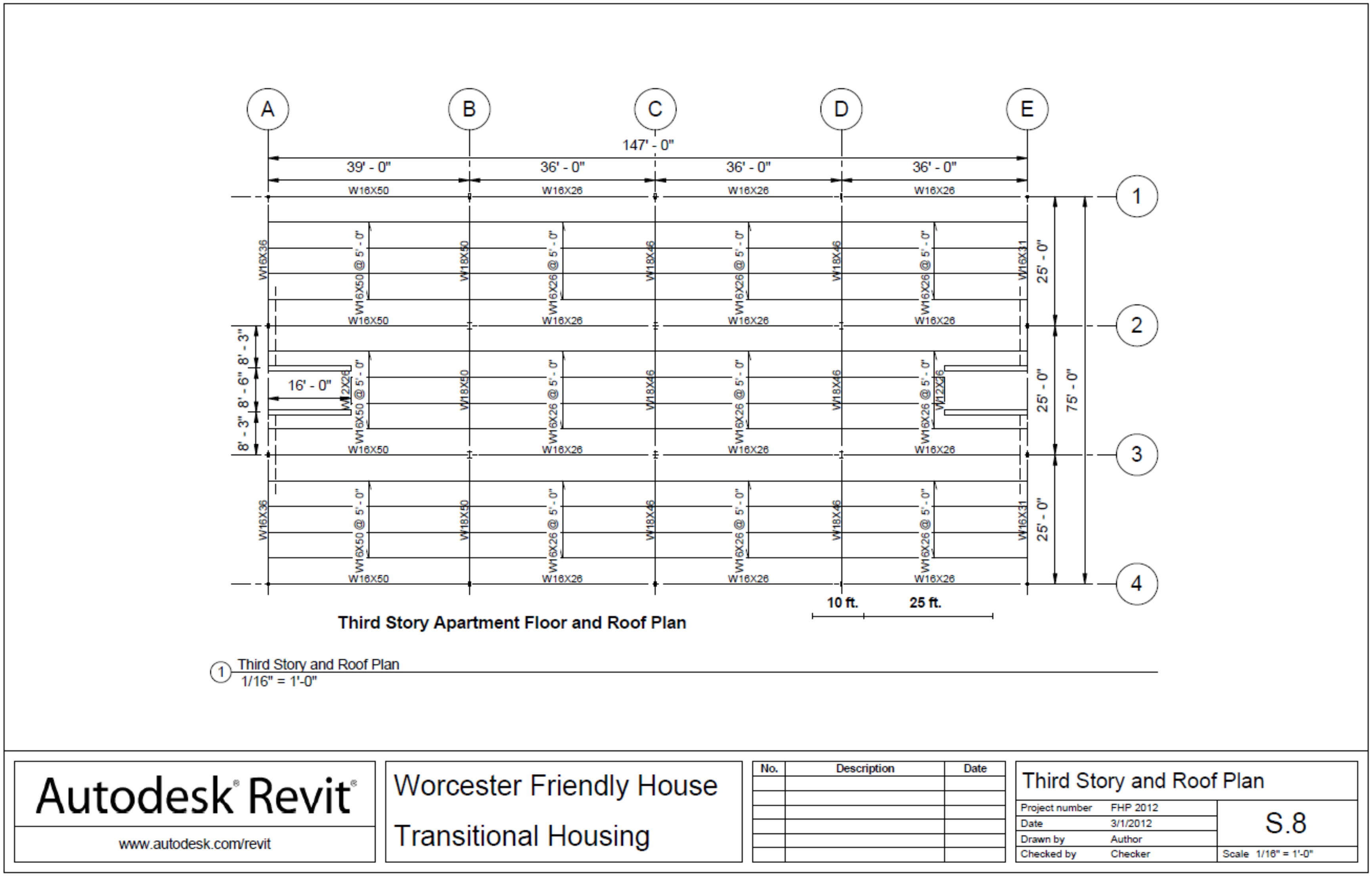


Figure 63: Third Floor & Roof Structural Layout

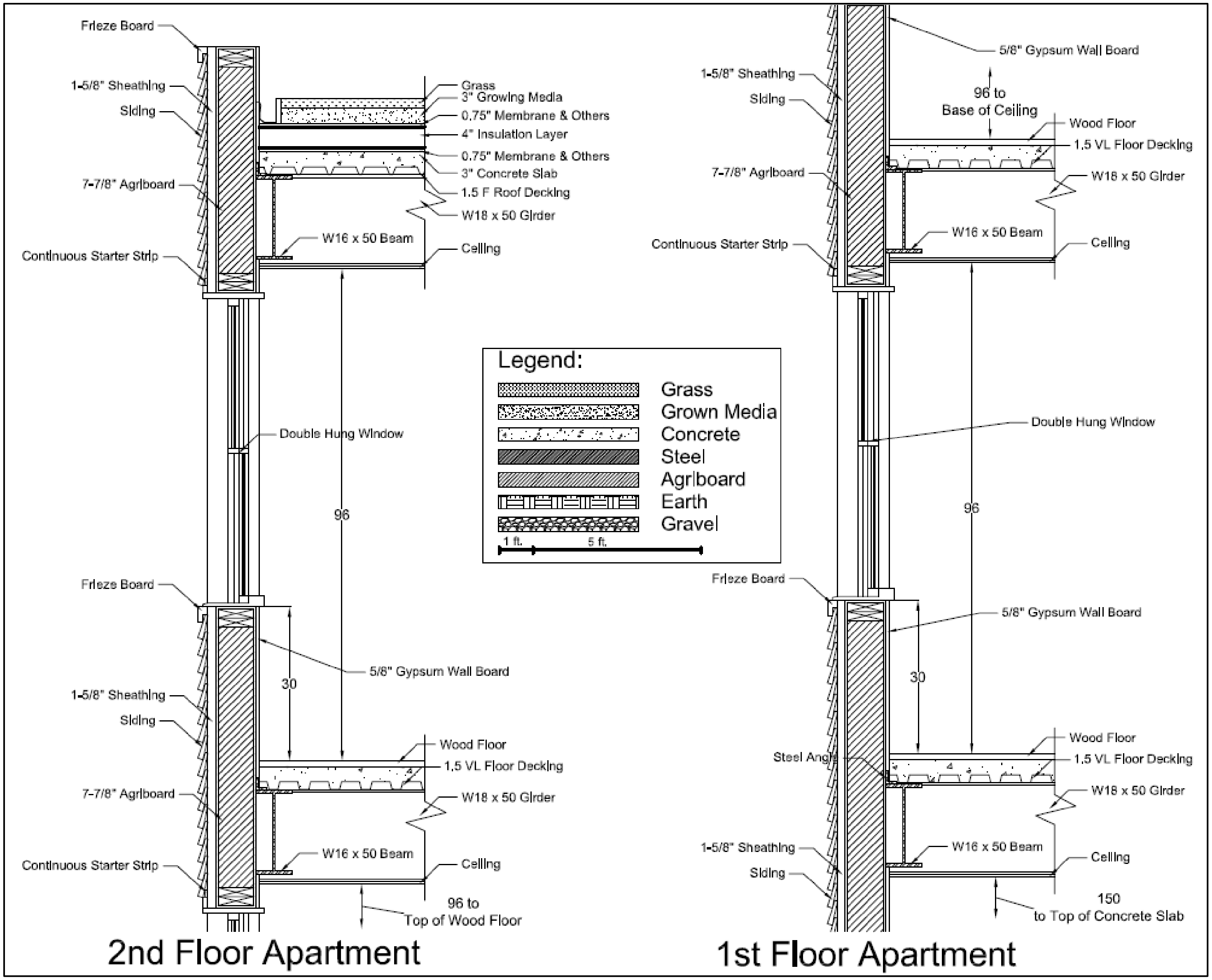


Figure 64: Detailed Cross Section 1

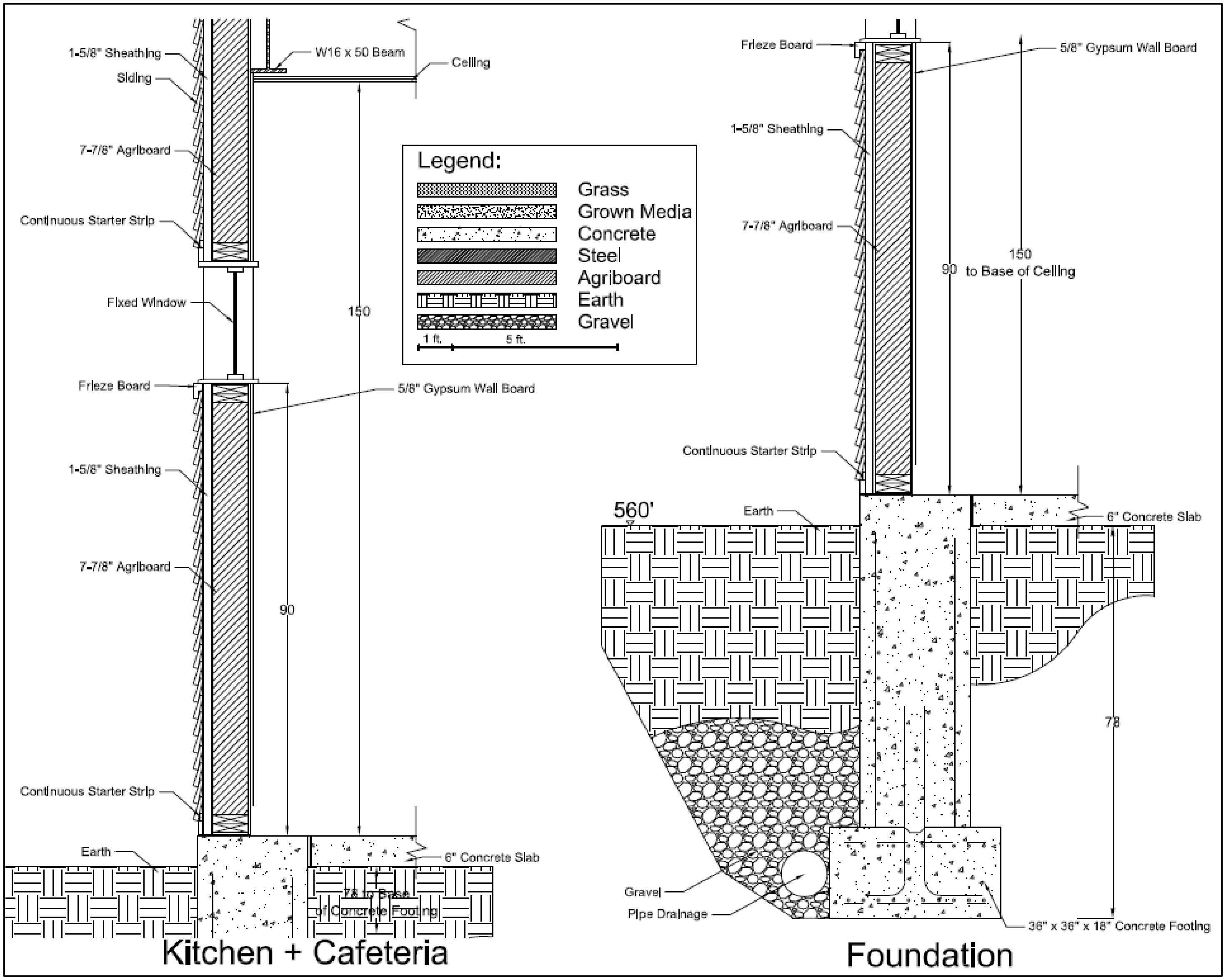
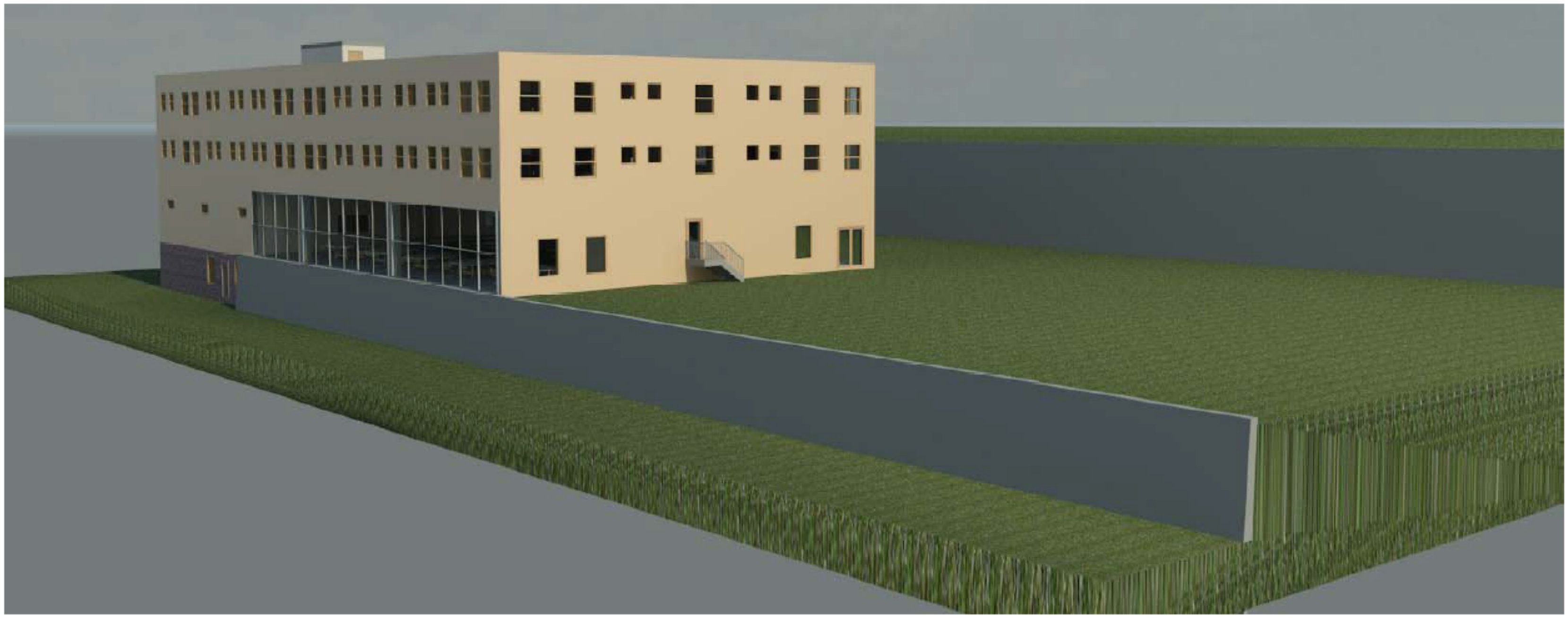


Figure 65: Detailed Cross Section 2



1 3D View 1_2
12" = 1'-0"

Autodesk® Revit®	Worcester Friendly House Transitional Housing	No.	Description	Date	Rendered House View 1	
www.autodesk.com/revit					Project number FHP 2012	A118
					Date 3/1/2012	
					Drawn by CCC	
					Checked by Prof. Pietroforte	Scale 12" = 1'-0"

Figure 66: Rendered House View 1

1 3D View 2_2
12" = 1'-0"

Autodesk® Revit®	Worcester Friendly House	No.	Description	Date	Rendered House View 2	
www.autodesk.com/revit	Transitional Housing				Project number FHP 2012	A119
					Date 3/1/2012	
					Drawn by CCC	
					Checked by Prof. Pietroforte	Scale 12" = 1'-0"

Figure 67: Rendered House View 2

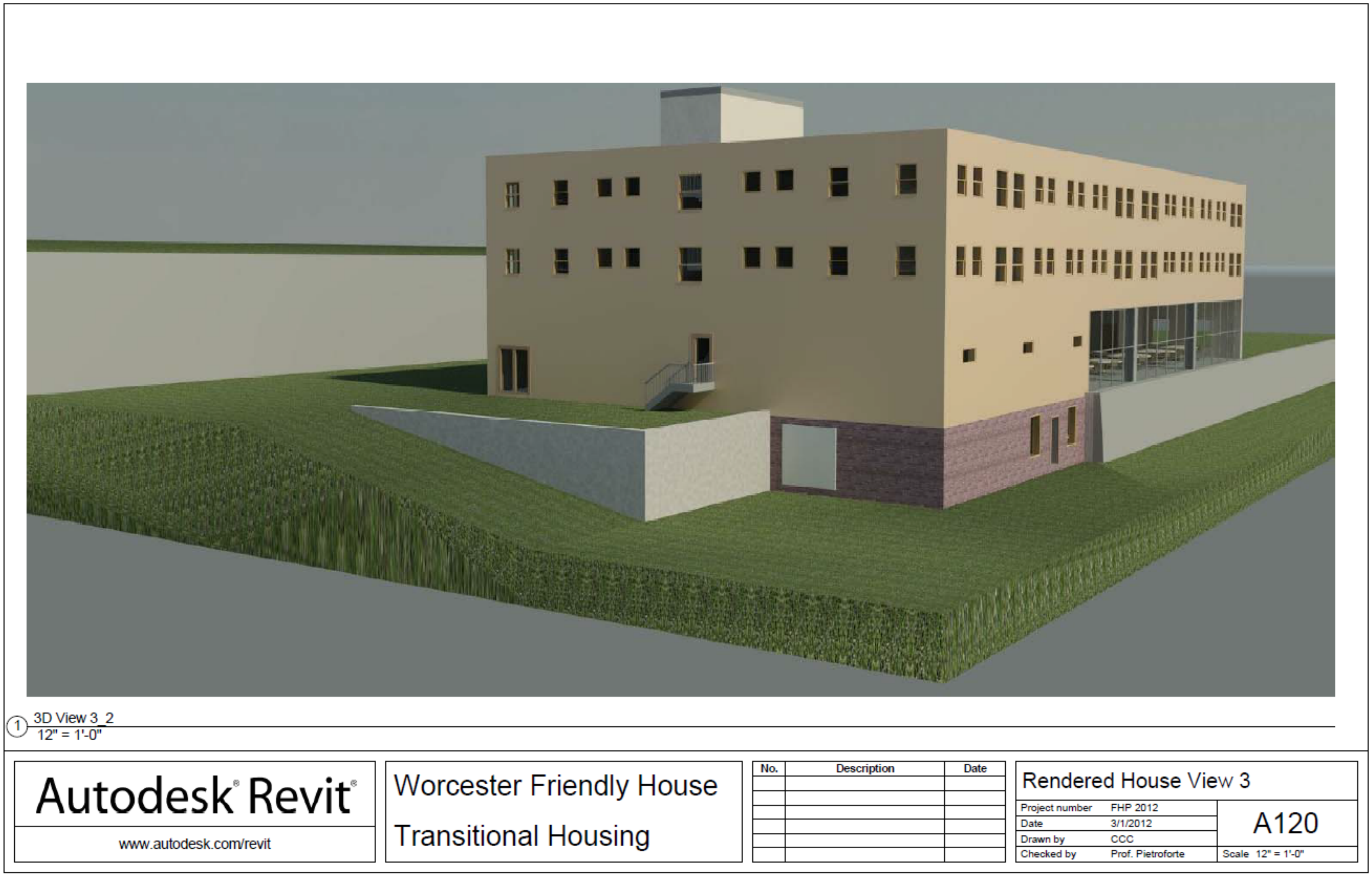


Figure 68: Rendered House View 3

1 3D View 4 2
12" = 1'-0"

Autodesk® Revit®

www.autodesk.com/revit

Worcester Friendly House

Transitional Housing

No.	Description	Date

Rendered House View 4

Project number	FHP 2012	A121
Date	3/1/2012	
Drawn by	CCC	
Checked by	Prof. Pietroforte	Scale 12" = 1'-0"

Figure 69: Rendered House View 4

1 3D View 5 2
12" = 1'-0"

Autodesk® Revit® www.autodesk.com/revit	Worcester Friendly House Transitional Housing	No. / Description / Date	Rendered Kitchen View (outside)

No.	Description	Date

Project number	FHP 2012	A122
Date	3/1/2012	
Drawn by	CCC	
Checked by	Prof. Pietroforte	Scale 12" = 1'-0"

Figure 70: Rendered Outside Kitchen View

1 3D View 6_1
12" = 1'-0"

Autodesk® Revit®	Worcester Friendly House	No.	Description	Date	Rendered Kitchen View (inside)		
www.autodesk.com/revit	Transitional Housing				Project number	FHP 2012	A123
					Date	3/1/2012	
					Drawn by	CCC	
					Checked by	Prof. Pietroforte	Scale 12" = 1'-0"

Figure 71: Rendered Inside Kitchen View

1 3D View 8_3
12" = 1'-0"

Autodesk® Revit® www.autodesk.com/revit	Worcester Friendly House Transitional Housing		Rendered Apartment View

No.	Description	Date

Project number	FHP 2012	A127
Date	3/1/2012	
Drawn by	Author	
Checked by	Checker	Scale 12" = 1'-0"

Figure 72: Rendered Apartment View

Appendix D: Detailed Cost Estimate and Schedule

Condensed Summary of Preliminary Cost Estimate

Category	Details	Total
Structure	Columns and Structural Framing	824458
Substructure	Footing, Slabs, Foundation Walls	121647
Shell	Floor Construction, Exterior Window and Doors	1068651
Interior Construction	Drywall, Floor Finish, Paint, Partitions	813649
Conveying	Elevator	62900
Plumbing	Water Closet System, Bath/Kitchen Sinks	312848
Heating and Cooling	Apartment A/C and Heating	467150
Fire Protection	Sprinkler System, Pipe Risers	142462
Electrical	Lighting and Branch Wiring, Communications	386500
Equipment & Furnishings	Washers, Dryers, Food Service Equipment	206356
Building Sitework	Earthwork, Roadways, Sewer	N/A
	TOTAL	4406620
	Expected Cost in March 2014 w/ Assumed 2% Inflation	4607401
	Expected Cost w/ Location Factor of 1.10	5068141
	Overhead and Profit (25% of Total Cost)	1267035
	GRAND TOTAL	**6335176**

Detailed Summary of Preliminary Cost Estimate

Category	Component	Details	Cost/Unit	Quantity	Unit	Total
Structure						
05 12 23.17	Column	HSS 5 x 4 x 3/8, 4 total	365	171	LF	62415
05 12 23.17	Column	HSS 10 x 4 x 3/8, 10 total	850	407	LF	345950
05 12 23.17	Column	W14 x 43, 6 total	96	236	LF	22621
05 12 23.75	Structural Framing	W12 x 26, 27 total	37	331	LF	12185
05 12 23.75	Structural Framing	W14 x 30, 3 total	42	49	LF	2046
05 12 23.75	Structural Framing	W16 x 26, 144 total	36	4868	LF	176562
05 12 23.75	Structural Framing	W16 x 31, 22 total	43	384	LF	16586
05 12 23.75	Structural Framing	W16 x 36, 18 total	55	284	LF	15550
05 12 23.75	Structural Framing	W16 x 50, 56 total	67	2025	LF	136384
05 12 23.75	Structural Framing	W18 x 46, 12 total	63	300	LF	18837
05 12 23.75	Structural Framing	W18 x 50, 9 total	68	225	LF	15323
					TOTAL	824458
Substructure						
A1010 110	Strip footing	24" x 12"	37	77	LF	2845
A1010 110	Strip footing	36" x 12"	42	64	LF	2704
A1010 110	Strip footing	46" x 12"	64	34	LF	2176
A1010 210	Spread Footing	36" x 36", Assume 6 Ksf	167	6	EA	1002
A1010 210	Spread Footing	26" x 26" x 18"	167	8	EA	1336
A1010 210	Spread Footing	18" x 18" x 12",	167	4	EA	668
A1010 320	Dampproofing	bituminous-one coat, 12'	16	100	LF	1559
A1030 120	Slab on Grade	6"-light industrial, reinforced	7	12275	SF	91694
A2020 110	Basement Wall	cast in place, 12' high, 12" thick	236	75	LF	17663
					TOTAL	121647
Shell						
B1010 256	Floor Construction	composite beams, deck and slab	17	33075	SF	567236
B1010 117	Split Face Block wall	Hollow 12 x 8 x 16 filled w/ perlite	17	2696	SF	47045
B2010 132	Brick Face Composite Wall	Double Wythe w/ concrete block	30	760	SF	23104
B2010 148*	Exterior Walls	Agriboard with wood siding ASFC	11	11653	SF	123871
B2020 102	Wood Windows	Combination of Double Hung and Fixed	486	143	EA	69498
B2020 220	Curtain Wall	Glazing Panel, 5/" thick, clear	26	2232	SF	56916
B2030 110	Aluminum Door	3' x 7'	1325	1	EA	1325
B2030 110	Aluminum Glazed Door	w/o transom 3' x 7'	2675	4	EA	10700
B2030 110	Aluminum Glazed Door	w/o transom 6' x 7'	4500	1	EA	4500
B2030 230	Aluminum/Fiberglass overhead door	heavy duty, manual open 12' x 12'	3580	1	EA	3580
B3010*	Roof Covering	Green Roof	15	10725	SF	160875
					TOTAL	1068651
Interior Construction						
C1010 126	Drywall Partitions	3-5/8"@24" O.C. 5" thick drywall both side	4	13448	SF	51102
C1010 126	Drywall Partitions	3-5/8"@24" O.C. 5" thick drywall on face	2	7808	SF	18583

C1020 102	Interior door	Single Leaf 3'x7'x1' 3/8" Solid Core	592	78	EA	46176
C1030 110	Toilet Partitions	floor mounted, plastic laminate	736	3	EA	2208
C1030 110	Toilet Partitions	floor mounted, plastic laminate, handicap	1051	2	EA	2102
C1030 111	Toilet Partitions	floor mounted, painted metal, int. Screen	333	1	EA	333
C1030 112	Toilet Partitions	floor mounted, plastic laminate, urinal Screen	330	2	EA	660
C1030 830	Fabricated Cabinets	hardwood base cabinet	383	160	LF	61200
C1030 830	Fabricated Cabinets	wall hardwood cabinet	533	160	LF	85200
C1030 831	Fabricated Cabinets	counter top, laminated plastic	28	160	LF	4544
C2010 110	Stairs	prefabricated wood w/ railings	2540	7	Per Flight	17780
C3010 230	Int. Paint and Covering	walls, ceiling and trim, primer and 1 coat	1	88586	SF	97445
C3020 410	Floor Finish	nylon, tufted carpet	9	17730	SF	164889
C3020 410	Floor Finish	Vinyl tile	4	4320	SF	18317
C3020 410	Floor Finish	composition flooring, 1/4" neoprene	9	5000	SF	44800
C3020 410	Floor Finish	Oak strip, sanded, finished	8	7200	SF	58608
C3030 110	Drywall Ceilings	1/2" painted, furring 16" O.C.	4	34325	SF	139703
					TOTAL	813649
Conveying						
D1010 110	Hydraulic Elevator	2500 lb. capacity, 2 floors	62900	1	EA	62900
					TOTAL	62900
Plumbing						
D2010 110	Water closet system	One-piece, Floor Mount	2170	22	EA	47740
D2010 210	Urinal System	wall hung	1355	2	EA	2710
D2010 310	Lavatory Systems	Cultured marble single bowl 25" x 19"	1300	16	EA	20800
D2010 310	Lavatory Systems	Vitreous China 18" x 15"	1485	5	EA	7425
D2010 410	Kitchen Sink System	steel enameled 32" x 21"	1675	16	EA	26800
D2010 420	Laundry Sink System	Double compartment 48" x 24"	1490	1	EA	1490
D2010 510	Bathtub System	Recessed, Mat bottom, 5' long	2420	16	EA	38720
D2020 250	Gas Water Heater	ASFC	4	34325	SF	151373
D2040 210	Roof Drains	ASFC	0	34325	SF	15790
					TOTAL	312848
Heating and Cooling						
D3010 510	Apartment Building Heating	Forced Hot Water, Fin Tube Radiation, ASFC	8	34325	SF	290390
D3050 170	Air cooling system	Split System ASFC	14	12275	SF	176760
					TOTAL	467150
Fire Protection						
D4010 410	Wet Pipe Sprinkler System	Loading Dock- Ordinary Hazard	4	1250	SF	4438
D4010 410	Wet Pipe Sprinkler System	Kitchen Area- Ordinary Hazard	4	11025	SF	47518
D4010 410	Wet Pipe Sprinkler System	Apartment Floors- Ordinary Hazard	4	22050	SF	78057
D4020 310	Wet Stand Pipe Risers	4" diameter	12450	1	EA	12450
					TOTAL	142462

Schedule Task Breakdown

ID		Task Mode	Name	Duration	Start	Finish	Early Start	Early Finish
1			**Site Preparation and Setup**	**60 days**	**Mon 3/3/14**	**Fri 5/23/14**	**Mon 3/3/14**	**Fri 5/23/14**
2			Demolition of Exsiting Houses	20 days	Mon 3/3/14	Fri 3/28/14	Mon 3/3/14	Fri 3/28/14
3			Site Cleaning	10 days	Mon 3/31/14	Fri 4/11/14	Mon 3/31/14	Fri 4/11/14
4			Site Grading	30 days	Mon 4/14/14	Fri 5/23/14	Mon 4/14/14	Fri 5/23/14
5			**Excavation and Foundation**	**140 days**	**Mon 5/26/14**	**Fri 12/5/14**	**Mon 5/26/14**	**Fri 12/5/14**
6			Excavation and Retaining Wall (20 ft.)	120 days	Mon 5/26/14	Fri 11/7/14	Mon 5/26/14	Fri 11/7/14
7			Excavation and Retaining Wall (10 ft.)	120 days	Mon 5/26/14	Fri 11/7/14	Mon 5/26/14	Fri 11/7/14
8			Install Utility lines	7 days	Mon 11/10/14	Tue 11/18/14	Mon 11/10/14	Tue 11/18/14
9			Footing and Foundation Wall	20 days	Mon 11/10/14	Fri 12/5/14	Mon 11/10/14	Fri 12/5/14
10			**Superstructure**	**109 days**	**Mon 11/10/14**	**Thu 4/9/15**	**Mon 11/10/14**	**Thu 4/9/15**
11			Erect Steel	28 days	Mon 12/8/14	Wed 1/14/15	Mon 12/8/14	Wed 1/14/15
12			Install Floor-Decking	7 days	Mon 1/5/15	Tue 1/13/15	Mon 1/5/15	Tue 1/13/15
13			Install Floor-Concrete Slab	41 days	Thu 2/12/15	Thu 4/9/15	Thu 2/12/15	Thu 4/9/15
14			Install Roof-Decking	3 days	Thu 1/15/15	Mon 1/19/15	Thu 1/15/15	Mon 1/19/15
15			Install Roof-Concrete Slab	41 days	Thu 1/15/15	Thu 3/12/15	Thu 1/15/15	Thu 3/12/15
16			Install Dumpweighter Shaft	5 days	Mon 11/10/14	Fri 11/14/14	Mon 11/10/14	Fri 11/14/14
17			Install Stairs	10 days	Thu 1/15/15	Wed 1/28/15	Thu 1/15/15	Wed 1/28/15
18			**Envelope**	**45 days**	**Fri 3/13/15**	**Thu 5/14/15**	**Fri 3/13/15**	**Thu 5/14/15**
19			Install Dumpweighter	5 days	Fri 5/8/15	Thu 5/14/15	Fri 5/8/15	Thu 5/14/15
20			Install Agriboard	15 days	Fri 4/10/15	Thu 4/30/15	Fri 4/10/15	Thu 4/30/15
21			Install Windows and Exterior Doors	20 days	Fri 4/10/15	Thu 5/7/15	Fri 4/10/15	Thu 5/7/15
22			Install Sheathing and Siding	10 days	Fri 4/17/15	Thu 4/30/15	Fri 4/17/15	Thu 4/30/15
23			Install Curtain Wall	10 days	Fri 4/10/15	Thu 4/23/15	Fri 4/10/15	Thu 4/23/15
24			Install Roof-Drainage Layer and Others	5 days	Fri 3/13/15	Thu 3/19/15	Fri 3/13/15	Thu 3/19/15
25			Install Roof-Grow Media and Other Green Roof Features	20 days	Fri 3/20/15	Thu 4/16/15	Fri 3/20/15	Thu 4/16/15
26			**Interior Construction**	**120 days**	**Fri 5/8/15**	**Thu 10/22/15**	**Fri 5/8/15**	**Thu 10/22/15**
27			Install MEP	50 days	Fri 5/8/15	Thu 7/16/15	Fri 5/8/15	Thu 7/16/15
28			Install Partitions	60 days	Fri 5/8/15	Thu 7/30/15	Fri 5/8/15	Thu 7/30/15
29			Install Interior Doors	10 days	Fri 5/8/15	Thu 5/21/15	Fri 5/8/15	Thu 5/21/15
30			Install Ceiling	40 days	Fri 7/17/15	Thu 9/10/15	Fri 7/17/15	Thu 9/10/15
31			Install Floor-Carpet and Wood	40 days	Fri 7/17/15	Thu 9/10/15	Fri 7/17/15	Thu 9/10/15
32			Install Bathroom	30 days	Fri 9/11/15	Thu 10/22/15	Fri 9/11/15	Thu 10/22/15
33			**Furniture, Fixtures and Equipment**	**40 days**	**Fri 7/31/15**	**Thu 9/24/15**	**Fri 7/31/15**	**Thu 9/24/15**
34			Install Commercial Kitchen and Cafeteria	40 days	Fri 7/31/15	Thu 9/24/15	Fri 7/31/15	Thu 9/24/15
35			**Paving and Landscaping**	**100 days**	**Fri 4/17/15**	**Thu 9/3/15**	**Fri 4/17/15**	**Thu 9/3/15**
36			Paving-Walk Way	40 days	Fri 5/1/15	Thu 6/25/15	Fri 5/1/15	Thu 6/25/15
37			Paving-Parking Lots	60 days	Fri 4/17/15	Thu 7/9/15	Fri 4/17/15	Thu 7/9/15
38			Paving-Sidewalk	30 days	Fri 5/1/15	Thu 6/11/15	Fri 5/1/15	Thu 6/11/15
39			Landscaping	40 days	Fri 7/10/15	Thu 9/3/15	Fri 7/10/15	Thu 9/3/15
40			finishing Project	0 days	Fri 10/23/15	Fri 10/23/15	Fri 10/23/15	Fri 10/23/15

Project Duration Bar Chart